BULLETIN

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THE INSTITUTE OF PHYSICS

AND

THE PHYSICAL SOCIETY

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Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute and Society necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute and Society for advice.

RESEARCH FELLOWSHIP IN APPLIED MECHANICS
ROYAL MILITARY COLLEGE OF SCIENCE
SHRIVENHAM, SWINDON, WILTS

Applications are invited from men for a Research Fellowship, tenable for three years, in Applied Mechanics. The work will involve fundamental studies in ablation and transpiration cooling techniques for high speed aircraft. The successful candidate will be expected to develop his own research equipment and adequate facilities are available for this purpose. Candidates must be British, with normally a First or Second Class Honours degree, with evidence of a very high standard of ability in research. Exceptionally, a candidate without the requisite academic qualification but who can produce evidence of outstanding ability in research may be admitted. At least two years postgraduate research experience required for J.R.F. (age preferably 23-26) and three years for S.R.F. (26-30). The work would be suitable for publication. Prior to expiry of Fellowship the holder, if under 31, can be considered for a permanent (pensionable) post. Remuneration according to individual merit on ranges £1,325–£1,640 (S.R.F.) and £910–£1,220 (J.R.F.). Superannuation under F.S.S.U. Details and Application Forms from Royal Military College of Science, Shrivenham, Swindon, Wilts, quoting reference HQ 79/33.

D.S.I.R. requires Scientific Officers/ Senior Scientific Officers at the Water Pollution Research Laboratory, Elder Way, Stevenage, Herts., for the following posts :—
(i) PHYSICAL CHEMISTS, preferably with good mathematical ability for research on physico chemical problems connected with treatment of industrial and domestic wastes and the effects of pollution on rivers and estuaries. Work includes laboratory studies and pilot plant investigations on unit processes, e.g. neutralization of acid or alkaline wastes and separation of solids from liquids in flocculating and non-flocculating suspensions (reference W.P.R.L.8 ZY). (ii) PHYSICIST, to work as a member of a team engaged in the development of indicating, recording and controlling instruments for use in the laboratory and field work in the study of rivers and the treatment of industrial and domestic wastes. The work is varied and covers a wide range of applications in physics, physical chemistry and nucleonics. The applicant should have a basic qualification in physics or physical chemistry, and an interest in electronics. Practical experience in instrument development or electronics, though desirable, is not essential (reference W.P.R.L.9 Y). Qualifications: 1st or 2nd Hons. degree in Physics or Chemistry. Salary ranges: S.O. £717 – £1,186. S.S.O. with at least three years postgraduate experience £1,302 – £1,604. Housing available in certain cases. Application forms from Director at the above address quoting appropriate reference number. Closing date September 15, 1961.

HUDDERSFIELD COLLEGE OF TECHNOLOGY
PRINCIPAL: DR. W. E. SCOTT, M.B.E.
DEPARTMENT OF PHYSICS

Required January 1, 1962, or earlier if possible, Grade B Assistant to teach physics. Salary (Burnham Scale) £700 p.a. by £27 10s. p.a. to £1,150 p.a. There are additions for approved qualifications and training and the commencing salary may include increments for approved industrial experience. Forms of application and further particulars obtainable from the Principal, to whom applications should be returned without delay. H. Gray, Clerk to the Governors.

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which arises from an increase in establishment. The teaching activities of the Department are primarily concerned with sandwich courses for the Diploma in Technology in Applied Physics together with Physics as an ancillary subject for other Diploma in Technology courses. Applicants should possess an Honours Degree, or an Honours Diploma in Technology in Applied Physics. It is desirable that applicants should have research or industrial experience in some branch of Applied Physics. The successful candidate will be required to join in one of the following fields of research : electron microscopy, solid state physics, X-ray crystallography.
Salary Scale: £930 × £27 10s. – £1,400 per annum. The starting salary will be dependent upon industrial or teaching experience. Further particulars and a form of application may be obtained from the Secretary.

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SENIOR LECTURER IN PHYSICS

Applications are invited for the above-mentioned post. The salary will be £1,750 rising to £2,000 per annum. The initial salary will be determined according to the qualifications and experience of the appointee. Approved fares to Wellington will be allowed for the appointee, his wife and his dependent children. In addition, actual removal expenses will be allowed within specified limits. Further particulars, and information as to the method of application, may be obtained from the Secretary, Association of Universities of the British Commonwealth, Marlborough House, Pall Mall, London, S.W.1. Applications close in New Zealand and London on September 30, 1961.

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Value £1,325 – £1,640 p.a. (Senior) and £910 – £1,220 p.a. (Junior). A very wide range of topics in PHYSICS, MATHEMATICS, CHEMISTRY, ENGINEERING, BIOLOGY, and other fields. Qualifications: normally first or second class honours degree; evidence of high standard of ability in research; and at least 2 years' postgraduate research experience (3 years for Senior Fellowships). Those completing these periods of experience in 1961 may apply. F.S.S.U. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting S/5244/61.

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DEPARTMENT OF PURE AND APPLIED PHYSICS
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Applications are invited for the above posts in the Department of Pure and Applied Physics from graduates or those of equivalent qualification. It is expected that the successful candidates will read for a higher degree or membership of the College of Technologists. Preference will be given to candidates interested in Surface Physics, Metal Physics or Acoustics. The values of the awards are £350 p.a., for Demonstratorships and £500 rising to £600 p.a. for Studentships. Further particulars may be obtained from the Acting Head of Department, Department of Pure and Applied Physics, The Royal College of Advanced Technology, Salford 5, Lancs.

METALLURGISTS

and

PHYSICISTS

required by the

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RESEARCH LABORATORIES

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Advancing conditions in steam generation necessitate fundamental and applied investigations into the behaviour of ferritic and austenitic steels at high temperatures under complex stress systems. Successful candidates will join teams working on problems associated with creep, fatigue, phase changes, erosion and oxidation. Postgraduate industrial or university experience in one of these fields is desirable but not essential. Excellent facilities for research are available and publication of results is encouraged.

These posts have arisen solely through a decision to increase our activity in these fields.

Applicants (preferably under 26 years of age) should possess a good honours degree or equivalent qualification. There are also a few vacancies for staff who are slightly less qualified academically, but who have particularly relevant experience.

● **Salaries up to £1,325 per annum (or higher in exceptional cases) will be fully commensurate with responsibilities, experience, ability and qualifications, and excellent prospects exist for promotion to higher grades.**

Applications stating age, qualifications, experience, present position and salary to the Appointments Officer, 24/30 Holborn, London, E.C.1. Quote "Ref. PB/315".

AUSTRALIAN ATOMIC ENERGY COMMISSION

RESEARCH ESTABLISHMENT

REACTOR PHYSICS

Applications are invited for the following senior positions in the Reactor Physics Section at the Research Establishment, Lucas Heights, N.S.W.

Grade: Senior or Principal Research Officer.

Salary: £2,395/2,720 or £2,980/3,500 (Aust.).

Duties: (Position R.18). To take charge of a group working on sub-critical and critical reactor problems and experiments associated with the AAEC high temperature gas-cooled reactor programme. Major equipment includes HIFAR, the 10 MW DIDO-class reactor and MOATA, the 10 KW UTR-10 type reactor.

Duties: (Position R.80). To carry out neutron physics studies both of a fundamental nature and also associated with the AAEC high temperature gas-cooled reactor programme, particularly neutron energy spectrum, spectrum, conversion ratio and resonance integral measurements, and general neutron reaction studies over a wide energy range.

Qualifications Honours or Higher Degree in Physics and several years' relevant experience.

Travel: Under specified conditions, first class air/sea transport for the appointee and dependants (wife and dependent children) will be provided.

Contract Employment: Consideration may be given to a contract agreement if the appointee desires to enter into an agreement for a three (3) year contract of employment in Australia. In this case, the AAEC will bear the cost of the return fares, together with assistance for removing the appointee's furniture and effects.

Applications: Forms obtainable from AAEC Liaison Officer, Australia House, Strand, London, W.C.2. OTHER POSITIONS are vacant in these groups in the Research and Senior Research Officer range, £1,510–2,265 and £2,395–2,720 (Australian). Enquiries to the above address.

PHYSICISTS

required by

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

for the Physics Group of the Fast Reactor Project at the Dounreay Experimental Reactor Establishment.

This Group is primarily concerned with experiments on the Dounreay Fast Reactor (D.F.R.) but its responsibilities go further and many of the experiments are designed to increase our general knowledge of fast reactor physics and, in particular, to anticipate problems concerning the design of future fast reactors.

A wide variety of calculations are made of the neutron flux and energy distributions, for a range of core compositions including possible and actual fuel loadings in D.F.R. The scope of the calculations is wide: they may involve simple methods or, for complex solutions, the use of high speed computers.

Theoretical methods are developed and applied to the investigation of the dynamic behaviour of fast reactors generally. The transient neutron flux is determined and used to evaluate thermal transients and finally reactivity transients. The response of the fuel, coolant and structure is computed and finally, the overall reactor characteristic.

D.F.R., previously run at only 1 MW will shortly become the world's highest flux fast reactor, presenting an opportunity to check the accuracy of neutron and gamma shielding calculations, especially for thick shields, and also the effect of the many possible streaming paths for radiation caused by coolant ducts, stepped plugs, etc.

Each of these theoretical programmes is complemented by experiment; e.g. flux distributions are measured in the reactor using fission counters and activation samples. The reactivity oscillator is used to examine the reactor dynamics and this apparatus will require development to improve its accuracy. Special shield plugs incorporating established and recently developed methods for monitoring neutron and gamma fluxes are being constructed.

To support this programme an analogue computer is available and a data link is provided to a " Mercury " computer. Access to a large analogue computer (PACE) and other digital computers is also available.

Appointments will be made, and starting salary assessed, according to age, qualifications and experience within the grade of

SENIOR SCIENTIFIC OFFICER—£1,440 to £1,770
OR SCIENTIFIC OFFICER—£790 to £1,310

Applicants should have at least a 2nd class honours degree in physics or mathematics, and for the senior grade at least three years approved research experience.

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Send postcard for application form to:—

Personnel Manager, U.K.A.E.A., Reactor Group, E.R.E., Dounreay, Thurso, Caithness,
quoting reference 253/110

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Postgraduate experience of theoretical research in related or other fields desirable.

Please apply to :

Technical Staff Officer, Dept. G.P.S., English Electric House, Strand, London, W.C.2, quoting reference PB913.X.

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Qualifications: Candidates (men or women) must possess or expect to obtain this year a first or second class honours degree in mathematics and/or physics. Experience in a Meteorological Service, especially in analysis and forecasting, useful but not essential. Successful applicants with no previous experience will be given training.

Duties: May include weather analysis and forecasting (including research); consultative meteorological work related to agriculture, hydrology, etc.; research into climatology, rain stimulation, evaporation control; work in the field of geomagnetism or solar radiation.

Terms of Appointment: On contract for tour of 24 months, with gratuity of 25% of salary on satisfactory completion. Salary in the scale £1,221–£2,448. Children's Education Allowances (e.g. £150 p.a. for first child at U.K. boarding school, £175 p.a. for second, £200 p.a. for third). Free family passages. Outfit allowance. Quarters at rental if available, otherwise house allowance payable. Generous leave. Medical attention available. Local rates of taxation. Apply to Director of Recruitment, Colonial Office, London, S.W.1, stating full name, age, qualifications and experience, quoting H6/BCD 57/88/01.

COMMONWEALTH **OF AUSTRALIA**

WEAPONS RESEARCH ESTABLISHMENT

INSTRUMENTATION PERFORMANCE ANALYSIS

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POSITION : SENIOR SCIENTIFIC OFFICER.
SALARY : £2,460 – 2,655 (Australian Currency).
(A substantial increase may be awarded shortly).
DUTIES : Lead a section engaged in the assessment of the accuracy of Range instrumentation involving theoretical studies of instrumentation systems and the design and analysis of special trials.
QUALIFICATIONS : Honours degree in Mathematics or Physics. Some experience in the assessment of instrumentation systems an advantage.
NOTE : Assistance will be given in obtaining married accommodation.
TRAVEL : Under certain conditions, first class air/sea transport for the candidate and dependants (wife and dependant children) will be provided by the Commonwealth.
CONTRACT EMPLOYMENT : Consideration may be given to entering into an agreement for a three (3) or five (5) year contract of employment in Australia.
In this case the Commonwealth will bear the cost of removing the successful applicant's furniture and effects up to a maximum cost of £500 (Australian); £250 each way.
APPLICATIONS : Forms obtainable from the Senior Representative (AV115/7), Department of Supply, Australia House, Strand, London, W.C.2, with whom completed applications should be lodged as soon as possible.

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or
PHYSICIST
(*with special interest in mathematics*)

There is a vacancy in the Company's Physics Research Department for the above.
An Honours Degree in Mathematics or Physics is required and some Research experience would be an advantage, but not essential.
The Department is mainly concerned with Research into the properties of special steels and the manufacture of large forgings. There is a varied range of problems including such matters as heat flow, residual stresses, etc., and statistics; there is an opportunity to use a computor. The Laboratories are in Sheffield within five miles of the Peak District National Park: Five-day week; Sports Club; Superannuation and Life Assurance Scheme; Salary commensurate with qualifications and experience. Applications to be made in writing to :—

The Personnel Manager,
THOS. FIRTH & JOHN BROWN LTD.
Atlas Works, SHEFFIELD, 4.

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COURTAULDS has vacancies for Physical Chemists and for a limited number of Organic Chemists and Physicists in one of its three Coventry Research Laboratories. The work in this Laboratory concerns the basic chemistry and physics of high polymers, particularly cellulose, with a view to the development of new man-made fibres and to the improvement of existing ones. Members of the Research Laboratories are eligible for transfer to Production work after initial experience in Research and Development.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds Limited, 16 St. Martin's-le-Grand, London, E.C.1, quoting reference number D.11/3.

BULLETIN
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Vol. 12, No. 8 AUGUST, 1961

Recent Advances in Alloys

R. W. CAHN
B.A., Ph.D., F.Inst.P.

University of Birmingham

[A paper given at a symposium* on new materials held by the London and Home Counties Branch on November 25th 1960]

RESPONDING to industrial challenges, especially from the aircraft industry and atomic energy, metallurgists have in recent years introduced a great variety of new alloys, quite apart from the novel metals, such as uranium, titanium and beryllium, whose technologies have been developed from scratch. Other alloys again have been studied purely for motives of scientific curiosity. A brief review can only touch on a few examples of what has been done; in making a selection for an audience of physicists, scientific interest is a proper criterion, in preference to present commercial importance.

A distinction must be made between alloys which owe their beneficial properties to elements held in solid solution in the base metal, and those in which one or more chemically distinct phases are held in dispersion.

SOLID SOLUTIONS

Normally, dissolving one metal in another has the effect of diminishing the capacity of the base metal for sustaining plastic deformation. A class of alloys has recently been discovered which breaks this rule. The addition of a substantial proportion of the precious metal rhenium to molybdenum or wolfram spectacularly increases the deformability of these inherently brittle metals.(1) Figure 1 illustrates the remarkable efficacy of such additions. The currently favoured interpretation is based upon the idea that the presence of rhenium alters the surface tension of molybdenum (or wolfram) oxide, an impurity which is always present, and thereby prevents it from forming a continuous, brittle film at grain boundaries.

This principle of setting one alloying addition to reduce the nuisance value of another, which is present as an unavoidable impurity, is increasingly employed by metallurgists. Thus it appears that small amounts of oxygen, if allowed to diffuse into " pure " copper, will under suitable conditions of gas pressure and temperature neutralize the effectiveness of some unidentified impurities in scattering electrons; in this way the addition of oxygen, an impurity, will actually increase the electric conductivity(2). Oxygen, which in large concentrations depresses the conductivity, can thus in small amounts actually confer a benefit.

Certain solid solutions have recently been made that by rights should not exist at all, since they are thermo-

Fig. 1. *Effect of rhenium in solid solution on workability of molybdenum. (The 50% Re alloy contains small amounts of a brittle second phase.)*(10).

* It is intended to publish all the papers given at the symposium in the *Bulletin*.

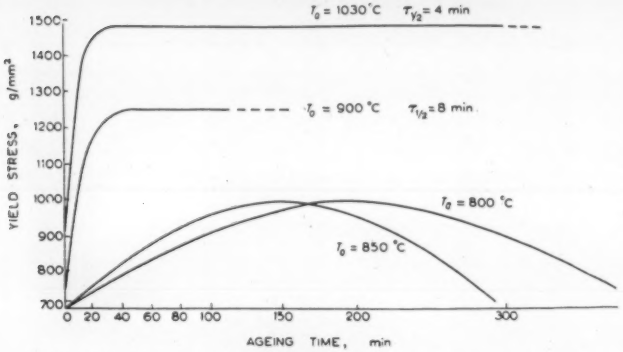

Fig. 2. *Age hardening at 100°C of quenched copper wire due to precipitation of vacancies*[4]. (T_Q *is quenching temperature.*)

dynamically unstable. Thus, in the course of experiments devoted to the study of superconduction in alloys, Buckel and Hilsch[3] evaporated mixed layers of tin and bismuth on to substrates cooled to 4°K, and produced and examined a whole family of tin-base solid solutions which do not exist in equilibrium, and break down when they are heated to room temperature.

Much attention has been devoted in recent years to the consequences of an alloying " element " which is never entirely absent, but which nowadays is manipulated with increased understanding; I refer to *nothing*. When a metal is heated, a small fraction of atoms jump out of their lattice positions and leave *lattice vacancies* behind. As the temperature increases, the equilibrium concentration of vacancies rises exponentially. Sudden cooling leaves the metal supersaturated with vacancies; they agglomerate into various geometrical shapes, which can be studied with the aid of an electron microscope, and this agglomeration can result in considerable hardening of the metal.[4] Some examples are shown in Figure 2.

The topical interest of studies of this kind is enhanced by the consideration that irradiation of all metals and alloys in nuclear reactors results in a large excess of lattice vacancies and other imperfections, which can result in unexpected behaviour. Thus Soviet scientists reported some years ago[5] that quite concentrated uranium-molybdenum alloys, which in equilibrium consist of two distinct phases, became single-phase under the influence of reactor irradiation. This is due to a sort of inverted quenching: minute groups of atoms become very rapidly heated to high temperatures, which turns them, quite properly, into the phase stable at such temperatures. Immediately afterwards, the temperature drops again, so rapidly that the new crystal structure is frozen in. However, under appropriate conditions, the large vacancy populations which are produced by irradiation can so accelerate diffusion in an alloy that its structure may change rapidly at room temperature. Thus age-hardening alloys can be particularly unstable in a reactor environment.

Allowing a solid solution to dissociate into two more stable phases has long been a standard technique for improving the mechanical properties of alloys. Some unusual examples of this technique have been reported. For instance, certain solid solutions are just barely stable at room temperature, so that application of a load can push them, so to speak, over the thermodynamic edge and initiate the formation of a second phase, which is associated with a macroscopic strain. If crystals of such an alloy are also incapable of plastic flow, then it is found that the amount of second phase is reversible with respect to the applied load; a large load transforms the alloy nearly completely, whereas removal of the load restores the alloy to its original condition. Rachinger[6] has used single crystals of one such alloy. containing copper, aluminium and nickel, to produce proving bars for testing electrical resistance strain gauges. These rings can accommodate reversible pseudo-elastic strains of as much as 2%, as often as is required, without destruction by fatigue. The stress/strain characteristics of a bar of this kind are shown in Figure 3.

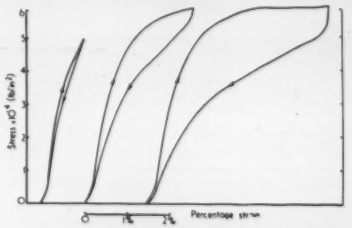

Fig. 3. *Stress-strain characteristics of Cu-Al-Ni " superelastic " alloy crystal*[6].

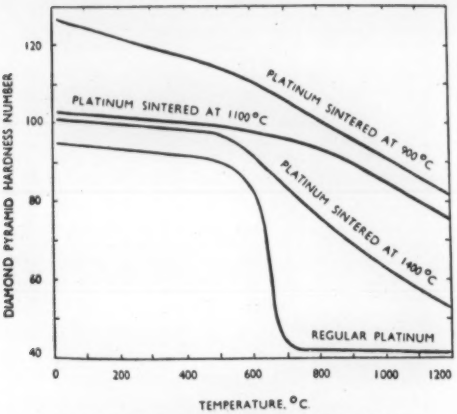

Fig. 4. *High-temperature hardness of platinum fabricated (a) from sintered compacts, (b) from regular cast metal*[7].

TWO PHASE ALLOYS

For an alloy to possess high strength, especially at elevated temperatures, it is essential for it to have a two-phase structure, with one phase finely dispersed in a matrix of the other. There have been many improvements in alloys of this type in recent years.

One form of " alloy " which comes under this heading is metal containing an assembly of small pores. This can be produced by heating a compact made by cold pressing the powdered metal. The particles sinter together, but if the metal is refractory, small pores remain in the final product. Experiments by Middleton, Pfeil and Rhodes[7] show that sintered and cold drawn pure platinum compacts prepared in this way are stronger, and keep their strength to higher temperatures, than do cast and cold-drawn wires of the same metal

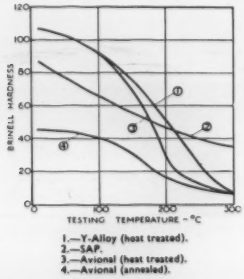

Fig. 5. *High-temperature hardness of Sintered Aluminium Powder (S.A.P.) and of some light alloys for aircraft use*[11].

(Figure 4). The pores are apparently resistant even to the drawing process, and their presence in the wire drawn from the sintered compact inhibits recrystallization at high temperature and thus promotes hot strength.

A related kind of alloy is sintered aluminium powder (S.A.P.), invented in Switzerland some years ago. When cold, S.A.P. not only is considerably stronger than ordinary cast and fabricated aluminium, but even excels some aluminium alloys. This superiority of S.A.P. becomes much more pronounced at elevated temperatures; whereas ordinary light alloys average and soften, S.A.P. retains its strength well at temperatures at which light alloys cannot be safely loaded, and its creep resistance is particularly impressive. S.A.P. owes these properties to the film of aluminium oxide which is produced on the surface of the powder flakes before sintering; the sintered compact contains a fine dispersion of aluminium oxide, which is not affected chemically by raising the temperature. Figure 5 shows some typical mechanical properties of this material.

A quite different method of attaining a similar end-product is known as " internal oxidation ". Dilute solid solutions of solutes such as aluminium, manganese, silicon or beryllium in copper or silver, in the form of sheets, are heated in an oxidizing atmosphere. The solutes are chosen for the high thermodynamic stability of their oxides, and consequently a layer of finely dispersed oxide gradually advances inwards from the surfaces of the sheet (Figure 6)[8]. By varying the nature and concentration of the solute, the temperature and the partial pressure of oxygen, the size of the individual oxide particles and the scale of their dispersion can be regulated. We are just beginning to establish the laws that relate these variables to the mechanical properties of the dispersion-hardened alloys.

Fig. 6. *Internal Oxidation. Alloy of copper + 0·4% manganese, oxidized at 1,000°C in air for eight hours. Polished and etched cross-section. (The darker region has been oxidized.)*[12] × 50.

A common feature of S.A.P., internally oxidized alloys and other similar products is the stability of their grain structure. The oxide particles are such effective barriers to the migration of grain boundaries that recrystallization is virtually impossible and cold-worked structures persist to high temperatures.

The method of sintering powder compacts is rapidly gaining importance, for alloys as well as for metals or metal/oxide mixtures. This principle has long been used for bonding extremely hard compounds, such as wolfram carbide, with softer matrix metals so as to manufacture hard but brittle cutting tools. Attempts are now being made to apply the same principle to making refractory dispersion-hardened alloys with some ductility but outstanding strength at high temperatures; this last requirement is coming rapidly to the forefront of metallurgical research, largely owing to the development of gas turbines, rockets and the like. By way of example, sintered compacts made of iron-aluminium solid solutions with varying proportions of titanium and chromium carbides prove to have very promising high temperature properties as well as good resistance to oxidation. Rapid advance may be expected in this area of development.

Understanding of the principles governing the behaviour of alloys, in terms of well-defined physical processes, has now developed to a point where it is occasionally possible to approximate to what every physical metallurgist would like to achieve, the *design*, from first principles, of an alloy with properties specified in advance. Thus Cochardt[9] has designed "NIVCO", an alloy for steam turbine blades, by making use of physical models relating damping capacity to certain ferromagnetic properties. Turbine blades must have a very high internal friction while under continuous load, so as to damp out the vibrations to which they are subjected by superimposed transient stresses while in service. This specialized requirement can be met by developing an alloy with quite specific magnetic properties (such as a high Curie temperature and high magnetostriction). Figure 7 illustrates the rotation of magnetic domains under stress, which is the physical process that underlies the internal friction of such alloys. It would not be correct to say that this alloy was "designed" in the full sense of the word, since some trial and error was still needed to find an alloy with the best magnetic properties; the vital point, however, is that the desired end-result, high damping capacity, was achieved obliquely, through sophisticated understanding of the physics of metals, by a research into more fundamental magnetic properties.

There is no space here to present the many specialized alloys which have been developed for the special purposes of the new industries of this age, such as atomic energy and transistor manufacture, nor to discuss the many physical curiosities that have been uncovered during physical studies of alloys. One could cite metals and alloys which contract on heating (plutonium), "metallic" alloys whose electrical resistance decreases as they are heated (e.g. Ti-Nb, U-Mo), ordered alloys (e.g. Cu-Pd) in which atoms behave as if they "sensed" the location of other atoms many atomic diameters distant. This kind of observation, though of purely academic interest, offers a considerable challenge to the physicists who often work in co-operation with metallurgists nowadays, and new problems present themselves more rapidly than old ones are interpreted. The science of alloys is in good health.

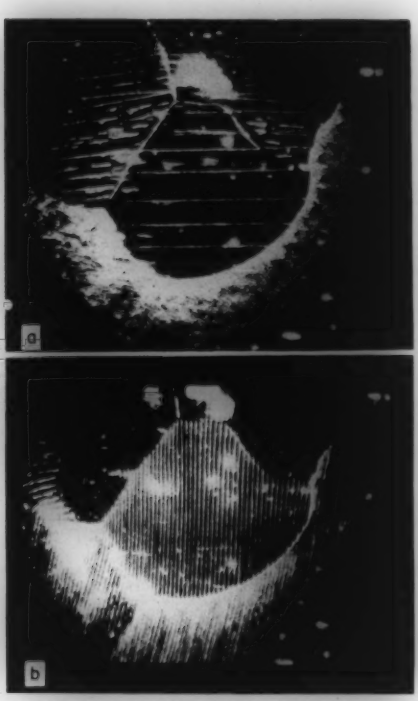

Fig. 7. *Re-orientation of magnetic domains under applied stress in polycrystalline silicon steel.* (*a*) *Without stress.* (*b*) *Tensile stress in vertical direction* [13] × 20.

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Bulletin of The Institute of Physics and The Physical Society

Students' Essays

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THE PURPOSE OF ESSAY WRITING

It is my business to teach physics. As part of this business I have always required students in my department to write essays—about one each term in the first two years and one in the final Part II examination. Most students are naturally sceptical about this activity, but I have a standard answer for them: "When you leave here, you will find yourselves, in the first place, judged more by your ability to express yourselves—in speech and in writing—than by your academic performance. A good degree helps, of course: but it is by no means the whole story". The students are, of course, unconvinced; but I still insist on the essays.

Almost all prospective employers agree with me. They are prepared to accept *our* academic evaluation of a man; but in addition *they* want to know if he can express himself reasonably well. For even if he is capable of the highest flights of intellectual thought he will be ineffective if he cannot say clearly what he thinks or if his writing is so dull that no one will persist in reading it. Students—bless their hearts !—may argue that scientists should not be judged in this way. But it is the business of people like me to acquaint them with the facts of life! The physicist must realize that writing is as important a part of his craft as the ability to design an experiment or to solve a differential equation.

For these reasons I regard essay writing as important, but there are also by-products. By careful choice of subject, the students are forced to read and so to use the library; they discuss the subjects (and presumably the imbecility of those who choose the subjects !) with each other; they are brought into close contact with a member of staff. The procedure is that each essay is marked by a member of staff, who is responsible for about a dozen essays in all. He makes corrections and comments, allots a mark, and hands the essay back to the student; after the student has digested the criticisms, the two discuss the essay together. Another valuable link is thus forged.

WHAT WE LOOK FOR IN ESSAYS

It is important for the essays to be critically read and quantitatively marked; a comment "fair" and a mark "β" are not enough. One is thus forced into considering what one is really looking for. The most important quality is what I call "readability" and it is not so difficult to assess. The perfect essay is written so well that one forgets all about minor points and reads it solely for the sake of finding out what is said. Any essay that I can read straight through is given full marks on that score; if I have to keep stopping for a rest it is medium; if I have to urge myself on all the time it is poor. Very few students write essays in the first category.

Readability however is not the sole quality to look for, and I assign marks under three different headings, which I call content, form and style. The first one is self-explanatory; an essay is expected to contain something worth saying. The subjects of the essays are carefully chosen to bring out the students' capabilities for saying something original. Purely physical subjects, such as "Magnetic Materials", which can be looked up in *Encyclopedia Brittanica*, are avoided. The best subject we have yet used was "Scientific Humanism" which made the students think, as physicists, about the world of ideas around them. It certainly taught *me* a great deal !

The form of an essay is concerned with the way in which the various parts are put together. To help the student to arrange his ideas logically, he is required to write—in grammatical English, not jottings—a synopsis of the essay; this also helps the reader to see what the student is trying to do and to assess how well he has done it. The various sections should be logically arranged and should flow naturally from one to the next, and the essay should finish properly; so many of them peter out aimlessly.

Style is the quality that most nearly decides the "readability" of an essay. It is the most evanescent quality, and the most difficult to inculcate. Some students have it, and others do not, and there is little one can do to help anyone who has no style. But what little can be done should be done, and the aim, as I understand it, is the following.

Ideally writing should resemble talking. Most students seem surprised at this statement; they have been brought up with the idea that written and spoken English are different. Of course, they are in a way. But in the same way that we do not have to choose our words and construction carefully as we speak, so we should not *appear* to choose them carefully as we write. In this naturalness lies the art of writing. Admittedly what we say is not usually recorded and used in evidence against us, but on the other hand what we write can be considered and reconsidered until we have exactly the right phrase for the occasion. (It can be reconsidered too often; the naturalness may disappear !).

PUNCTUATION

In speech however we have a number of advantages that we do not have in writing; there are changes of tone and of emphasis, there are pauses and facial expressions. In writing, these are replaced by a very poor substitute—punctuation. In the same way that a good physicist has a good working knowledge of all the laws of physics, so the good writer should make use of all the punctuation marks available to him. The poorest students—the-cat-sat-on-the-mat school—use only full stops, and the reader is pulled up sharply at the end of each sentence. Normally students use only full stops and commas, which admittedly can do quite well. But why not try the full

range—colons, semicolons, question marks, quotation marks, dashes and all, as detailed in Fowler's *The King's English?* Hyphens also can be used much more than they are to make a description unambiguous; there is a difference between a "single crystal photograph" and a "single-crystal photograph". Italics can be used to give emphasis to a word, but only to *one* word at a time; there is in speech no parallel to the italicising of a group of words.

The perfect author is, in my opinion, Lewis Carroll. The test is that his works—at least, those with which I am familiar—can be opened at any page and read *aloud* without any previous preparation. I often try this test on students with their own essays after they have had a chance to forget what they have written!

GRAMMAR, SPELLING AND CLICHÉS

Minor details such as grammar and spelling look after themselves; faults break the reader's train of thought and so affect the impression of style. Particularly depressing is the use of jargon (not of course good physical jargon, which is part of our stock in trade); it indicates that the student is prepared to use ready-made phrases rather than to find his own words. "The present position . . .", "The political situation . . ."—phrases such as these show insufficient regard for the meanings of precise words such as "position" and "situation". "Due to . . .", "due to the fact that . . .", "as to . . ." also suffer from similar disadvantages. For the same reason, I try to induce students to avoid using all-embracing words such as *case*, *get*, *do*, *this*, and *thing*; I tell them to try to find the right word and to use it. They do not always succeed, as I do not myself, but the effort is worthwhile.

For similar reasons, I tell the students not to make lists—a, b, c . . .—in their essays; they are a substitute for grammatical writing. They should not use formulae and equations or draw diagrams. The exercise is on the use of *words*.

APOLOGIA

But who am I to judge other people's use of words? What training have *I* had in marking essays? Should I not hand them over to an expert in English who would know exactly how to assess them? No. I believe that a physicist's essays should be judged, however amateurishly by a fellow physicist. Only *he* will know how a physicist thinks, how he should use his words. *He* will know the relative weight to put upon an unattached participle and a misuse of the word "power". Unrepentantly, I keep the marking of the essays within the department. Anyhow, looking critically at other people's writing improves one's own.

I also realize quite clearly that the rashest act a man can perform is to write an article about writing. I can envisage each reader polishing up his own foibles and getting ready to fling them at me. "How can anyone who professes to criticize others bring himself to write so-and-so?" All right; I have asked for it. In the same way that physics has progressed by the nearly-blind guiding the blind, so perhaps can a poor writer give a few faint hints to others who also find the subject difficult.

But I humbly ask pardon of any of my readers whose shibboleths I have broken. I have not broken them intentionally.

ILLITERATE SCIENTISTS?

One hears so much these days of the illiterate scientist that I should like to take this opportunity of stating my views about my own students. There is a modern—or perhaps not-so-modern?—tendency for people to overstate a case, and my students at least may be glad to know that I do not consider them illiterate. There are one or two who come perilously close to knowing nothing about the structure of their language, but there are also some whose writing I consider myself presumptuous to criticize. Most of the essays are dull and uninteresting, but can we expect better from students at their stage of education with their enforced rate of study? Their spelling is sometimes odd—"developement" is the commonest mistake—but is there a perfect speller anywhere? Handwriting is reasonable; according to my secretary some of the staff have much worse.

Unless I have an unusually gifted set of students, I am sure that the jibe of "illiterate scientists" is wrong; it has been produced by people who want to make an impression. The phrase has been used so often that people now believe it. I hope that if this article does nothing else it may induce some people to think again about the accusation.

ACKNOWLEDGMENTS

I should like to take this opportunity (cliché?) to thank the members of my staff who have joined so whole-heartedly in this essay scheme. I must also add that we have differences of opinion and the views expressed in this article are entirely my own. I would particularly thank Dr. Steeple who is responsible for choosing the subjects.

Notes and News

Final General Meeting of The Institute of Physics

NOTICE IS HEREBY GIVEN that a General Meeting of The Institute of Physics will be held at 47 Belgrave Square, London, S.W.1, on the third day of October, 1961, at 5 p.m. to receive the Account of the Liquidators showing how the winding up of the Institute has been conducted and its property disposed of, to hear any explanation that may be given by the Liquidators and to pass an Extraordinary Resolution (given hereunder) as to the disposal of the books, accounts, and documents of the Company.

A member entitled to attend and vote at the above meeting may appoint a proxy to attend and vote instead of him.

Extraordinary Resolution. That the books, accounts and documents of the Institute be handed over by the Liquidators to The Institute of Physics and The Physical Society to be retained by them for a period of not less than three years.

E. W. COLEMAN
H. R. LANG
Joint Liquidators.

August 18, 1961
47 Belgrave Square,
London, S.W.1.

NOTE. Only those who were Fellows or Associates of The Institute of Physics on July 5, 1960 are entitled to attend the above meeting or to vote in person or by proxy.

Final General Meeting of The Physical Society

NOTICE IS HEREBY GIVEN that a General Meeting of The Physical Society will be held at 47 Belgrave Square, London, S.W.1, on the third day of October, 1961, at 5.10 p.m. to receive the Account of the Liquidators showing how the winding-up of the Society has been conducted and its property disposed of, to hear any explanation that may be given by the Liquidators and to pass an Extraordinary Resolution (given hereunder) as to the disposal of the books, accounts and documents of the Company.

A member entitled to attend and vote at the above meeting may appoint a proxy to attend and vote instead of him.

Extraordinary Resolution. That the books, accounts and documents of the Society be handed over by the Liquidators to The Institute of Physics and The Physical Society to be retained by them for a period of not less than three years

E. W. COLEMAN
A. C. STICKLAND
Joint Liquidators.

August 18, 1961
1 Lowther Gardens,
London, S.W.7.

NOTE. Only those who were Fellows of The Physical Society on July 5, 1960, are entitled to attend the above meeting or to vote in person or by proxy.

First elected Council

In the April issue of the *Bulletin* members were reminded that the first Council of the amalgamated body was appointed by the Board of the Institute and the Council of the Society as a " caretaker Council " to hold office until September 30, 1961. This " caretaker Council " nominated its successor and invited alternative nominations from members in accordance with the constitution of the new body.

At the first Annual General Meeting of the amalgamated body held in London on July 4 there being no other nominations the President declared the following duly elected to take office on October 1 next.

President: Sir John Cockcroft, *Vice-Presidents:* Dr. V. E. Cosslett, Professor R. W. Ditchburn, Dr. W. H. Taylor, and Dr. J. Topping, *Honorary Treasurer:* Dr. J. Taylor, *Honorary Secretary:* Dr. C. G. Wynne, *Ordinary members of Council:* Professor C. C. Butler, Mr. E. R. Davies, Professor B. H. Flowers, Dr. J. M. A. Lenihan, Mr. G. R. Noakes, Professor C. F. Powell, Dr. F. A. Vick and Professor D. A. Wright. In addition the President mentioned that Dr. M. R. Hopkins and Professor A. M. Taylor would serve on the Council having been elected by the Annual Representative Meeting to represent the Branches on the Council in accordance with Article 47.

First Annual General Meeting

At the first Annual General Meeting of the amalgamated Institute and Society held on July 4 at headquarters the Annual Report for 1960 and the accompanying Accounts as circulated to members in the May *Bulletin* were duly approved and adopted. The President declared those nominated duly elected. Messrs. Knox Cropper, Gedge & Co. of Spencer House, South Place, London, E.C.2 were appointed Auditors at a fee to be agreed by the Council.

A very cordial vote of thanks was accorded to the members of the caretaker Council and particularly to the President, Sir John Cockcroft, who had been good enough to give an immense amount of his time and thought to many matters which have had to be considered during this " caretaker " period. The members were also particularly grateful to the Honorary Treasurer, Dr. James Taylor who had had a very heavy year in dealing with the amalgamation of the finances of the Society and of the Institute and who had been responsible for the successful appeal for the Physics Trust Fund. Dr. Wynne, the Honorary Secretary had also devoted much time and thought to the establishment of the administrative machinery of the amalgamated body and matters requiring day to day attention during this settling down period. A special vote of thanks was accorded to the retiring members of the Council, Sir George Thomson and Mr. J. A. Ratcliffe, the Presidents of the original Institute and Society respectively at the time of their winding up, who were ex-officio members of the caretaker Council, Mr. Philpot who was the Vice-President responsible for the Exhibitions and Professor H. Lipson who served as a representative of the Branches

and has done much in connexion with the educational work of the Institute and Society.

On the President's proposal a hearty vote of thanks was passed to the Honorary Officers of Branches and Groups at home and oversea for all their work and also to the universities and colleges, sister Institutions and other bodies who have been good enough to allow the Institute and Society the use of their rooms for meetings during the year.

University of Reading: Mr. J. S. Burgess

Former students and staff at the University of Reading Physics Department will be interested to learn that Mr. J. S. Burgess is retiring from the post of senior technician after loyally serving the University for over 50 years. Former members of the Department who would like to be associated with a presentation to be made to Mr. Burgess to mark his retirement are invited to send a contribution (maximum 10s.), together with their name and the date they entered the Department, to The Secretary, J. J. Thomson Physical Laboratory, Whiteknights Park, Reading.

Speakers' Timer

The Institute and Society is indebted to the Central Electricity Research Laboratories, Leatherhead, for the gift of an instrument for timing speakers at meetings and conferences. The timer which can be set for any period in the range 3 to 72 minutes employs a system of coloured lights ending with a red light accompanied by chimes. It was successfully used by the Stress Analysis Group at its Annual Conference in Southampton in April of this year, and is available for use at meetings and conferences sponsored by Branches and Groups.

The Structure and Properties of Ionic Melts

The Faraday Society has arranged a general discussion on The Structure and Properties of Ionic Melts to be held at the University of Liverpool on September 5-7, 1961. The last date for applications is August 22. Full details may be obtained from The Assistant Secretary, The Faraday Society, 6 Gray's Inn Square, Gray's Inn, London, W.C.1.

Symposium on Electromagnetic Theory and Antennas

A Symposium on Electromagnetic Theory and Antennas will be held in Copenhagen from June 25-30, 1962. Anyone wishing to submit a paper or to attend the symposium should write for details to H. Lottrup Knudsen, Secretary, Symposium on Electromagnetic Theory and Antennas, Øster Voldgade 10G, Copenhagen K, Denmark.

International Association for Cybernetics

The International Association for Cybernetics is holding a Congress in Namur on September 11-15, 1961. Anyone wishing to attend should write to the Secretary, of the Association at 13 Rue Basse-Marcelle, Namur, Belgium.

International Science and Technology

A new monthly publication *International Science and Technology* is to be published by Conover-Mast Publications of New York. It will be sent free of charge, to scientists and engineers engaged in research and development engineering. Any Members of the Institute and Society who would like to have this publication sent to them monthly from January next should notify the Secretary of the Institute and Society at headquarters.

Chinese for Scientists: An Introductory Course

The Department of Extra-Mural Studies of the University of Bristol proposes to hold an introductory course in Chinese for scientists in the session beginning in September, 1961. There have been several requests for such a course, following the success of similar courses in Russian, and with the considerable increase in the number of scientific journals being published only in Chinese the demand is expected to grow.

The plan of study provides for a total of about 35 to 40 hours tuition, spread over five week-ends which follow at fortnightly intervals beginning on September 30. Meetings will be held in the Department of Extra-Mural Studies, 20a Berkeley Square, University of Bristol, Bristol 8. The inclusive fee for tuition for the course for five weekends is £5 5s. 0d. Details may be obtained from the Director of Extra-Mural Studies, University of Bristol, Bristol, 8.

Symposium on Spectroscopy

The Hydrocarbon Research Group of the Institute of Petroleum will hold its third Symposium on Spectroscopy in the William Beveridge Hall of the University of London from March 28 to 31, 1962. It will be similar to those held in 1954 and 1958 and will review progress in many spectroscopic fields. These will include : Infrared and Raman spectroscopy, Nuclear and electron spin resonance, Spectra of free radicals, Vacuum ultraviolet spectra and ionization potentials, X-ray fluorescence and atomic absorption spectra. The full programme and registration forms will be distributed later but applications for attendance or further details should be sent to : The General Secretary, Institute of Petroleum, 61 New Cavendish Street, London, W.1.

News of Soviet Science and Technology

Seventeen of the leading Russian technical journals are translated into English and published every month by British research associations and scientific societies for the Department of Scientific and Industrial Research. These provide up-to-minute information on Soviet progress in steel manufacture, castings, welding, rubber and plastics, production engineering, machines and tooling, instrument construction, textiles, wood processing, chemistry, biology and mathematics.

The Department also sponsors the translation and publication of Russian technical books, and each year places on sale translations of hundreds of technical articles. These translations are obtainable from the new National Lending Library for Science and Technology, in Boston Spa, Yorkshire, which also has available on loan a further 20,000 individual translations. Enquiries should be addressed to The Director, National Lending Library for Science and Technology, Boston Spa, Yorkshire.

Conference on Microwave Measurement Techniques

The Electronics and Communications Section of the Institution of Electrical Engineers will hold a conference on Microwave Measurement Techniques from Wednesday, September 6 to Friday, September 8, 1961. Application forms are obtainable from The Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

B.C.A.C.: First Annual Lecture

Dr. D. G. Christopherson, O.B.E., F.R.S., Pro-Vice-Chancellor of the University of Durham and Warden of the Durham Colleges, has accepted an invitation to give the first annual lecture of the British Conference on Automation and Computation (B.C.A.C.). His subject will be " Mathematics—Friend or Foe ? ". The meeting will be in the Lecture Theatre of The Institution of Electrical Engineers, Savoy Place, London, W.C.2, on Wednesday, September 27 at 5.30 p.m.

The lecture is open to all members of the 31 member societies of B.C.A.C. (of which the Institute and Society is one); others should apply for tickets (free) from the Honorary Secretary, B.C.A.C., c/o The Institution of Electrical Engineers, Savoy Place, London, W.C.2. Tea will be served at 5 p.m.

Appeal for the Physics Trust Fund

The following donations or subscriptions were received between June 23 and July 23, 1961:

(*a*) From members

Mr. M. I. Andrews
Mr. B. S. Bassan
Dr. H. F. Buckley
Dr. A. C. Chapman
Mr. J. E. Egleton
Mr. E. V. Gilby
Mr. C. R. Haynes
Miss Nora E. Hill
Mr. H. A. Hughes
Dr. S. E. Hunt
Mr. R. C. G. Killean
Mr. I. B. S. Law
Mr. M. E. Peplow
Dr. J. H. Phillips
Prof. M. Pirani
Mr. A. G. Razzell
Mr. M. J. Richard
Mr. L. Rotherham
Mr. G. Rowlands
Mr. T. Shingler
Mr. J. H. W. Simmons
Dr. J. E. Wood
Mr. R. Wood
Dr. W. H. Willott

together with two donations from members who wish to remain anonymous.

(*b*) From firms

Beckman Instruments Ltd.

The total received in donations or promises (including tax recoverable on covenanted subscriptions) was on July 23, £112,992

The

GUTHRIE LECTURE

of the Institute and Society

will be delivered on

Thursday, 21 September

at 4.30 p.m.

in

The Physics Department,

University College of North Wales, Bangor,

during the conference on Radiospectroscopy

of solids

Dr. D. Shoenberg, F.R.S., will speak on:—

The de Haas-van Alphen effect and the electronic structure of metals

Tickets are not required

ELECTRONICS GROUP

Conference on

THE PHYSICS OF GAS DISCHARGE DEVICES

September 28 and 29, 1961

at

LEAMINGTON SPA

Topics to be considered will include:

Energy measurements in modulator thyratrons—comparison of the properties of hot cathode thyratrons containing the three isotopes of hydrogen—non-thermonuclear applications of high temperature discharges—problems of arc control—heavy current switching—very high current mercury pool switches—thermionic energy converters—gas-filled thermionic converters with ion injection—gas discharges as wave propagation devices—stabilizing tubes—corona stabilizers—surface emission of electrons by secondary processes in gas discharges.

A limited number of hotel rooms are available but bookings must be made as soon as possible. Information regarding hotel bookings and programs and application forms may be obtained from the Administration Assistant of the Institute and Society.

X-RAY ANALYSIS GROUP

AUTUMN CONFERENCE

on

IMPERFECTIONS IN CRYSTALS

November 17 and 18, 1961

at

The Institution of Mechanical Engineers, London

Session subjects will be as follows:

The nature of crystal imperfections and of associated diffraction effects.

Experimental methods for studying imperfections. Effects on physical properties.

Included in the invited speakers will be Dr. P. B. Hirsch, F.Inst.P., of the University of Cambridge, and Professor F. C. Frank, O.B.E., F.Inst.P., F.R.S., of the University of Bristol.

Enquiries regarding the program should be addressed to the Honorary Conference Secretary, Dr. G. S. Parry, A.Inst.P., Department of Chemical Engineering, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

Registration is necessary. Further particulars and application forms may be obtained from the Administration Assistant of the Institute and Society in early September.

The Institute and Society is arranging

a Symposium on

"Some aspects of the physics of space research"

to be held at the

Royal Military College of Science, Shrivenham

from

20 - 22 September, 1961

Subjects to be discussed are:

The advantages to physicists of space research
Cosmic rays, particle physics and meteorology
Radio research from rockets and satellites
Rockets, orbits and trajectories

The Symposium will be residential. Further details may be obtained from the Administration Assistant of the Institute and Society.

Reviews of Books

ELEMENTS OF MASER THEORY

By Arthur A. Vuylsteke

London: D. Van Nostrand Co. Ltd. Pp. xiii+362. Price 71s. 6d.

In his preface to this comprehensive book the author points out that in " the relatively new science of *Quantum Electronics* which has as its primary aim the practical utilization of the quantum behaviour of matter . . . it is necessary to combine, in a more obvious fashion than has heretofore been apparent, the principles and techniques of a number of allied but distinct disciplines ". To define and map out the ground which the practitioners of these " allied but distinct disciplines " must make common, Dr. Vuylsteke has written this volume " in which the necessary, basic physical theories are presented as an introduction to a rather complete discussion of that part of maser theory which is most basic and which is presently well understood ".

The result is a concise, extensively mathematical text of some 352 pages, probably not quite so self-contained as the author hopes—the phrase " it can be shown " occurs rather frequently in the later pages, usually preceding statements which derive from quantum mechanics —but certainly representing a massive feat of organization. After an introductory chapter of 32 pages, which surveys the whole field of the book and is designed to whet our appetite for work and insight, there follow chapters on *quantum mechanics* (67 pp.), *statistical mechanics* (37 pp.), and *the interaction of matter and radiation* (50 pp.). This basic theory occupies more than half the book; the applications follow in the next four chapters on *the maser: two-level excitation* (49 pp.), *maser levels in electron paramagnets* (58 pp.), *the maser: three-level excitation* (27 pp.), and *maser noise* (17 pp.).

It is interesting to see how the ultimate purpose of the book shapes the development of the general theory in the early chapters. Thus, in undergraduate texts on quantum theory the subject is usually built up from consideration of simple systems—the hydrogen atom, the simple harmonic oscillator, the deuteron—and quantum statistics may be introduced *via* the properties of many-electron atoms and molecules, and the exclusion principle. Vuylsteke, on the other hand, is aiming to treat the quantized interactions of macroscopic systems, and his axiomatic development of quantum mechanics leads into statistical mechanics and the equations of motion of the statistical matrix. The chapter on *the interaction of matter and radiation* then treats the interaction between quantized radiation fields, material assemblies and constant-temperature baths. Atomic and molecular physics comes later, when ideas about atomic structure are required in the chapter on electron paramagnetism. This development is carefully planned and seems entirely satisfactory, though the axiomatic approach, which is increasingly used in textbooks now, calls for a good deal of preparation—or maturity—on the part of the reader.

The book will in fact be heavy going for many of those for whom it is intended, and some will find the pace in the later chapters fierce indeed, as the " it can be shown "-s multiply, and familiarity with the techniques of microwave circuit calculation is assumed without any such prefatory gambit. Nevertheless, this is an invaluable guide through the theoretical background and established conclusions of an important and stimulating field, and the effort it calls for should be rewarding. There are very few oversimplifications to lull and delude the painstaking reader, the logical elisions are usually accompanied by references to a representative bibliography, and the material is expertly marshalled.

The book is published at a time which ensures its welcome, it is well produced, and, all things considered, reasonably priced. One notes from the preface that " the book was written as a specific project at the Research Laboratories of the General Motors "—a case of what's good for General Motors being good for a lot of other people too !

R. M. Sillitto.

ELECTROMAGNETIC STRUCTURE OF NUCLEONS

By S. D. Drell and F. Zachariasen

London: Clarendon Press: Oxford University Press. Pp. 111 Price 12s. 6d.

This book is intended to give " a critical review and analysis of recent studies of the electromagnetic structure of nucleons ". A short introductory chapter is devoted to the basic definitions of the form factors. The two main parts of the book are the second chapter, dealing with the interpretation of the various experimental results in terms of form factors (which actually involves a considerable amount of theoretical analysis), and the third chapter, which deals with the various attempts to calculate the form factors in terms of basic assumptions about elementary particle interactions. The short final chapter raises the question of the validity of quantum electrodynamics at small distances, and hence of the validity of some of the definitions introduced in the first chapter when applied to very high energy experiments.

This arrangement of the contents is the natural way in which the various problems in the field of nucleon electromagnetic structure divide up for such a " critical review and analysis ". However, much of the detailed contents and the preface (where it is said that Chapter III should serve " as a first introduction to dispersion methods ") suggest that the book is intended as an introductory text for students quite unfamiliar with the field. In many places this compromise between an introduction and a critical review results in making it not very satisfactory as either. For example, some of the discussion of Chapter II has to do with analytic properties of transition amplitudes and would be extremely hard to understand for anyone who really needed the " introduction to dispersion methods " in Chapter III.

The book will probably be most useful as a comprehensive survey of the present status and " jargon " of the nucleon electromagnetic structure problem, for research workers with a good background in the theory of elementary particles, and, as such, is a welcome

addition to the literature. Typographically, it gives the impression of being somewhat cramped, so that complicated formulae look more confusing than they might. However, this may be partially explained by one of the most attractive features of the book—its extremely moderate price.

RONALD F. PEIERLS.

TRAVELLING-WAVE ENGINEERING

By R. K. Moore

London : McGraw-Hill Publishing Co. Ltd. Pp. xix+360. Price 85s. 6d.

The book deals with distributed parameter systems, i.e. those systems in which any distribution has a finite propagation time. It is, of course, common for electrical engineering undergraduates to study transmission lines in network problems in detail usually divorced from other related phenomena in physics such as the characteristics of vibrating strings, the conduction of heat, or indeed related diffusion phenomena such as those encountered in the kinetic theory of gases. Students of physics are often, or should be, better treated but even so in their earlier years they may well not be given " propagation physics " in its widest possible and most coherent sense. In their later years such things are, or should be, self evident to students.

This book takes a wide view of the field but with a predominantly electrical outlook. There are short chapters on travelling electromagnetic waves and on the general application of wave equations to transverse waves on membranes and strings, acoustic waves in fluids and " mechanical waves " in solids, etc.; also on transient travelling waves, including transient studies of diffusion processes, on steady state travelling and stationary waves, travelling waves in lines, lumped constant models (artificial lines), transmission lines for communications and power distribution and impedance charts and matching, etc. The final chapter is on oblique incidence plane wave reflections and spherical waves.

The book is expensive but to be recommended more to electrical engineering students or to physicists with special electrical interests than for general physics reading.

J. D. CRAGGS.

SERVOMECHANISMS

By P. L. Taylor

London : Longmans, Green & Co. Ltd. Pp. xiv+418. Price 42s.

In reviewing this book I have tried to bear in mind that it is one of a series on electrical engineering subjects, and is written by an electrical engineer for (presumably) students of electrical engineering. Furthermore, much of the subject matter of automatic control has been developed in the context of electrical or mechanical engineering. But I believe that the physicist's approach to this subject is—and rightly so—very different from that adopted by the author of this book : his emphasis for most of the book is on the way of doing things, rather than on the nature of what is done. In consequence, although the book is well-written, nicely produced and, in terms of quantity, excellent value for money, I hesitate to recommend it to physicists commencing the study of automatic control : those who have already acquired some familiarity with the subject are not likely to be interested anyway, as it is essentially an introductory textbook.

I find the form of the book difficult to understand. One result of the arrangement adopted is that the development of the essential ideas of the subject is continually interrupted in order to introduce descriptions of apparatus. Thus, after a very elementary introductory chapter we have two chapters on data transmission and computation before being allowed to continue with the study of simple servomechanisms for one chapter. Following this are seven chapters—about one-quarter of the book—on components such as amplifiers, motors, etc., and then another chapter on the equations of motion of control systems. Even then, however, the way is not clear, since there are chapters on linear systems, complex variables and the Laplace transform before we finally reach a series of chapters on the theory of servomechanisms. To some extent, this arrangement is accounted for by the sub-division of the book into three parts, but even this must be queried. In the book as a whole there is undoubtedly material enough for a satisfactory course on servomechanisms, even though the arrangement may not be to everybody's taste. But over three-quarters of the discussion of servomechanisms as such (as distinct from components) is in Part III—and the author suggests that Parts I and II together could form the basis of a course for National Diploma and Ordinary Degree students. It is difficult to see how such students could acquire much understanding of the subject in this way.

One feature of the arrangement that seems to me to complicate the subject unduly is that the properties of negative feedback amplifiers are discussed after the introductory analysis of simple servomechanisms and after the chapter on computation. This means that the discussion of the use and properties of operational amplifiers for computation is necessarily somewhat sketchy. It also means that the subject of feedback control is not introduced in what seems to me the most satisfactory way, i.e. via the properties of familiar amplifier circuits. (Incidentally, there seems to be no indication in this book that feedback is not necessarily negative.) Another peculiarity is that the idea of a relationship between gain and phaseshift is not introduced until the last few pages of the book—and then only in terms of the full Bode analysis.

A very useful feature of the book is a large and varied collection of problems (and answers) which should be of great value to the student in testing his understanding of each of the topics discussed.

A. E. DE BARR.

X-RAYS—THEIR ORIGIN, DOSAGE AND PRACTICAL APPLICATION

By W. E. Schall

Bristol : John Wright and Sons Ltd. Pp. xi+348. Price 50s.

" Schall ", as this book is known amongst radiographers, is understandably held in esteem by them

because, since it first appeared in 1923, it has been one of the few textbooks covering the physics and apparatus part of their training. It is regrettable, therefore, that this latest member of the line (it is the eighth edition) can only be given a hostile reception.

The author specifically states that his object has been " to avoid mathematics as much as possible . . . " and " . . . to say what he wants to say in plain English . . . ". This approach works quite satisfactorily for the first six chapters from which the reader may gain a clear, qualitative picture of the basic physics involved in the production of X-rays and of the apparatus used. In later chapters the English is plain but the principles being described are often not.

A disturbing feature of the book is the attention given to ideas or apparatus which are obsolete, and the amount of it which has remained unchanged since 1928 in spite of many advances. For example, four pages are devoted to the gas tube and its behaviour; most of the dosemeters described ceased to be used twenty years ago, and the Tables on X-ray percentage depth doses are completely outmoded. Though the seldom used curved " Potter-Bucky " diaphragm is described, no mention is made of oscillating or reciprocating grids that have been in use for a long time.

It is, however, against the sections involving the biological effects of radiation that strongest exception must be taken. The author states that he is " . . . a complete layman in matters of X-ray therapy " and proceeds to demonstrate it in no uncertain manner. He is just not in touch with modern thought and practice in radiotherapy nor in relation to the general problem of exposing people to radiation. Otherwise he would not suggest that, in diagnostic radiography " mistakes can be overcome by repeating exposures without risk of doing harm ", nor would he include a table which is based on a permissible dose of 100 r in three weeks from diagnostic radiography and which, in that period, would allow 60 radiographs of the stomach to be taken ! Neither would he include a description (unchanged since the second edition) of an " auxiliary concentrating filter " which not only is never used, but which would never have the properties attributed to it.

There are too many dangerous statements and errors of fact in this book for it to be recommended, in spite of the usefulness of its opening chapters.

W. J. Meredith.

PARTIAL DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS

By H. Bateman

London: Cambridge University Press. Pp. xxii + 522. Price 27s. 6d.

"A book which no working mathematical physicist can afford to be without " wrote E. T. Whittaker in reviewing an earlier edition of this classic. Thanks to the production by the Cambridge University Press of this inexpensive edition, there is no reason why anyone should be without it if he wants it. First published in 1932, it still ranks as an authoritative and comprehensive source book of solutions by analytical methods of boundary value problems in mathematical physics. It has of course dated a little. What are probably regarded nowadays as the most powerful techniques based on integral transforms are not to be found. They are only mentioned briefly under the heading of Heaviside calculus. Solutions are obtained mostly by d'Alembert's method and by the separation of variables.

Older readers of the *Bulletin* will be well aware of the contents of this book. Younger readers may like to know that the partial differential equations included are the wave equation, the heat flow or diffusion equation and the Laplace equation. Solutions are obtained in one, two and three variables, some of them referred to cartesian, polar, cylindrical, ellipsoidal, paraboloidal and toroidal coordinates. Topics introduced incidentally are the integral theorems of Green and Stokes, Fourier series and integral and conformal representation.

This is in the nature of a treatise rather than an introductory text book. It is most suitable for those who, having already some acquaintance with the subject, wish to plunge more deeply. There is a good supply of examples of different degrees of difficulty.

J. Crank.

MATHEMATICS IN YOUR WORLD

By Karl Menninger. Translated by P. S. Morrell and J. E. Blamey

London: G. Bell & Sons Ltd. Pp. viii + 244. Price 21s.

This is a welcome addition to an ever-growing list of books (several from the same publisher) which seek to cater for the layman who is—or can be—interested in mathematics. Publishers must think, or perhaps have evidence, that readers of this type of book are on the increase: we may well hope that they are right. Not everybody, perhaps, can become a professional mathematician, but many are capable of understanding more than they themselves—or others—might think; and much technological and other progress would be easier if more people could view more problems with more mathematical understanding.

" We come across mathematical principles everywhere, but remain only hazily aware of their real nature and significance. This book attempts to present familiar phenomena from our own surroundings, and to show how a mathematician would think about them. Traditional nomenclature has been avoided, lest the reader think he has fallen among pundits: and there remains an incomparable kingdom of riches for our attention".

The author's introduction—drastically condensed—should give an accurate and attractive picture of his book, which is translated from the German in a fluent and intimate conversational style, in keeping with the use of the familiar " *deiner* " in the original title. The mathematics here involved is definitely of the " applied " variety, and physical principles are concerned in many of the topics discussed.

An early section deals with implications of change of scale, and shows why we need not expect to find mice the size of elephants, elephants jumping like fleas, or giants smoking cigars; a later section considers gradients and curvatures as we meet them when travelling by rail or

road. Other sections consider statistics and probability, with applications to industrial inspection procedures, to roulette and (German!) football pools, and also to life assurance.

Standardization is discussed, with illustrations from DIN paper sizes, involving preferred numbers in a near-geometric sequence. A comparison is made with equal temperament for musical scales, appositely enough; but the reader could wrongly be left thinking that an octave might as well have been divided into *any* number of divisions—so long as the frequencies were in geometric progression, to make all the musical intervals equal. There is more to it than this: preferred numbers and musical scales have in both cases to obtain *good* approximations to whole numbers, using geometric progressions in which the *actual* whole numbers are impossible; and this raises further points of mathematical interest.

Interspersed with all this will be found some discussion of the infinity of primes, perspective, the drawing of ellipses, time-distance graphs, bees' cells, exponential growth, and curves of constant breadth: also the briefest of mentions of some recreational problems—permutational, logical, coin-weighing, Nim; these latter might deserve more space or better treatment.

The reviewer feels strongly that a book like this should maintain impeccable accuracy in what it handles; it loses some value—and authority—if there are errors which its readers can find out. Hence the points of criticism which follow:

It is misleading to call the curve of quickest descent a *half*-cycloid. For zero velocity initially, the curve must begin at a cusp of the cycloid; then the cycloid must be drawn to a *scale* which will pass its first (inverted) arch *through the other terminus*: a cycloid has only one possible *shape*, and the path need not—and in general will not—be horizontal, at the lower terminus.

The transition curve corresponding to the path of a car which maintains constant speed as its steering wheel is uniformly rotated is the *Cornu's* spiral, or *clothoid*, which is involved also in diffraction in optics—*not* an equiangular spiral, which is another name for a logarithmic spiral; and a whole section invites some confusion by using the words "parabolic" and "catenary" in both loose and strict senses, indistinguishably. The curve of a cornstalk is *not* a true parabola, whereas the catenary of a suspension bridge *is* one, assuming first-approximation idealizations; the true catenary (of an unloaded uniform chain) is something else again.

Whole numbers are called prime numbers, in error, at one point; "1 *and* 3" is used for "1 *or* 3" in relation to unsafe positions in the game of Nim. "Degree of bending"—for beams—is used where "deflection" is meant; it might be thought to mean angle of curvature and Zeno (of the paradoxes) deserves better than to be consistently called Xenon, as if he were a gas.

These criticisms are offered in the hope that authors (or translators) and publishers read reviews, and may make corrections in the future editions which this book deserves. For all that, it remains a most desirable addition to all school libraries; and many adults also could enjoy it, and benefit from it.

T. H. O'Beirne.

MICROSCOPY OF RUBBER

By C. H. Leigh-Dugmore

Cambridge: W. Heffer & Sons Ltd. (For the Institution of the Rubber Industry). Pp. vi+72. Price 25s.

In this little book the author has attempted to present a systematic account of the ways in which optical and electron microscopy have been applied to the study of rubber and related polymers. Microscopical techniques as such are not discussed, but a chapter on methods of preparation of specimens (sectioning, replication, etc.) is included. The space given to the various subjects reflects the amount of published work devoted to them. Thus the study of latex—the size and distribution of rubber and non-rubber constituents, changes on coagulation, etc.—receives considerable attention, as does also the question of the structure of carbon black and other compounding ingredients in vulcanized rubbers. In these developments the advantages of the electron microscope in giving the necessary resolving power are very evident.

The last chapter deals with applications of microscopy to the study of abrasion, tearing, adhesion and other subjects of technical importance, in which considerable progress has recently been made.

The treatment throughout is rather condensed, but readable, up to date and extensively referenced. The twenty-five photographic reproductions are well chosen and add considerably to the value of the book.

L. R. G. Treloar.

A SOCIAL HISTORY OF ENGINEERING

By W. H. G. Armytage

London: Faber and Faber. Pp. 378. Price 42s.

This book has much to commend it, but the author will not expect his ambitious theme to command universal acceptance, if only because different people would emphasize points which he discusses rather briefly, and vice versa. However, he sets out to examine the circumstances which brought about the chief technological advances in man's history, and also the result upon society at large. There can be no doubt that it is well to pause awhile sometimes and to look both backwards and forwards. Yet these pages give an indefinable sense of discomfort. A mass of material is passed in review (most of it very well known and accessible already), giving the impression of a monumental effort in reading and correlation, without adding a great deal to what everybody is thinking. True, this is social history, not science, and by this criterion it should be assessed. The upshot tends to be fair comment indeed, but leaves one pondering what "the object of the exercise" is. The probability would seem to be that anybody reading the book would have enough of historiography already to appreciate the environment at any time, and sufficient deductive power to sense the effects and the "moral" almost at once.

Nevertheless, certain valuable features emerge. The Greeks' contribution to knowledge is well reviewed, and their reluctance to experiment partly explained by their belief that putting nature to the test would be impious. This, as the writer says, is connected with the

view that life is to be understood rather than altered. Basically, of course, this amounts to the recognition that there is an implied conflict between axiology and technology: little, however, is suggested to resolve it, still less to sublimate it in the minds of men. St. Thomas Aquinas was more courageous; he advocated experiment at the same time as adapting Aristotle to a powerful system of Christian apologetics. Professor Armytage might well have included Gilson's *The Spirit of Mediaeval Philosophy* as a make-weight, and by no means a biased one, to give the reader something to live by.

And so we approach the turbulent sixteenth and seventeenth centuries, when confidence was running high, and Francis Bacon tried to establish an inductive system for research, which would ensure man's mastery over nature for good or ill. Yet the Royal Society was founded with very practical aims, but without absorbing the Baconian doctrine in its most inhibiting form.

Professor Armytage continues the story up to our own day—ships, railways, planes and the rest, as well as the development of resources for obtaining power on a national scale. All this is very well done. The text is accompanied by a well chosen series of portraits, some of them unusual, and not readily accessible.

The proof-reading cannot have been above reproach; there are some needless mistakes. For example, Hariot for Harriot, Magdalene for Magdalen (a sad lapse this, for a professor of education), Menton for Merton.

If one is left perhaps with the feeling that this could have been a better book, that does not diminish our gratitude to the author for giving us a substantial amount to think over.

F. I. G. Rawlins.

ELEMENTARY STATISTICS

By Paul G. Hoel

New York and London: John Wiley & Sons, Inc. Pp. vii + 261. Price 44s.

A book entitled *Introduction to Mathematical Statistics* by the same author has long been in use as a text for a one-year course to science students with mathematics up to elementary calculus. The book under review was designed for a shorter course, also for science students but with even less mathematics.

The result is two books which are complementary; for, in the reviewer's opinion, much of what is said at length in the elementary book is what a lecturer would need to say in supplement of the more mathematical text. The lapse of some twelve to thirteen years between the writing of the two is another reason for recommending the use of the two together.

Most books on the subject, even the elementary ones, have treated the methods of statistics as essentially mathematical; that is in each case the author's prime purpose has seemed to be to state or prove the properties of randomly arising variates, usually confusing their role as models with which real experience can be compared with reality itself. There is a trace of this attitude in the present book notably in the presentation of the rules for compounding probabilities by means of an *experiment* with a coin. The introductory chapter on "The nature of statistical methods" if given the study it ought to have should produce the correct attitude to the remainder of the book.

The thirteen chapters follow a fairly conventional pattern (the one entitled "Testing Hypotheses" is the seventh) but is the result of the author's lengthy teaching experience. The last six chapters are labelled as "special topics" and their subjects receive only the short treatment that might be expected from the short duration of the designed course. The analysis of variance is, for example, dealt with in twelve pages yet manages by means of an example to introduce the idea of design for experiments. Two unusual chapters for this kind of book deal with time series and with non-parametric tests respectively.

Each chapter has a fair number of exercises, mostly numerical, to the odd numbered ones of which the answers are given. All the necessary tables are reproduced in appendices.

E. D. van Rest.

APPLIED OPTICS AND OPTICAL DESIGN, PART II

A. E. Conrady

New York: Dover Publications Inc. London: Constable & Co. Pp. 323. Price $2.95.

The posthumous publication of part two of Professor Conrady's classic textbook on the techniques of optical computing and design will be regarded as an important event by many of his former pupils and readers. The work of assembling and editing the manuscript and of completing the numerical examples has been carried out by Dr. Rudolph Kingslake and a brief biographical note and a bibliography of Professor Conrady's publications are included. The present volume is a direct continuation of the first, commencing with further examples of computation by the thin-lens method and then progressing to design techniques based on the computation of optical path differences. Particular reference is made to microscope objectives and photographic lenses.

This volume should be of interest as a work of reference to practical designers; it may be especially valuable, because of the detail of the argument and the fully worked examples, to students working alone.

C. A. Taylor.

OPTICS AND OPTICAL INSTRUMENTS

By B. K. Johnson

New York: Dover Publications Inc. London: Constable & Co. Pp. viii + 224. Price $1.65.

This book is an unaltered republication under a new title of the second (1947) edition of the author's *Practical Optics*. It is difficult to see why the title has been changed; this is a practical handbook which might appeal most to amateurs or to industrialists who need to make use of optical techniques to assist research in other fields. The theory begins with elementary discussions of reflexion, refraction and thin lenses, and the various formulae of geometrical optics are stated without mathematical development. Instructions are given, however, for the carrying out of experimental verifications and, as the main

features of optical instruments are introduced, experimental models are suggested on which the principles may be demonstrated. A few of the diagrams and blocks are taken from very old publications and this gives the book a curiously " old-fashioned " air. A valuable feature is the collection of practical hints and recipes concerned with the working, cleaning and testing of optical surfaces.

C. A. TAYLOR.

DIGITAL COMPUTER AND CONTROL ENGINEERING

By R. S. Ledley

London: McGraw-Hill Publishing Co. Ltd. Pp. xxiv + 835. Price 112s. 6d.

This book claims to be the most comprehensive textbook so far published on the subject and this is a claim that is justified. The title may be misleading as there is by far more attention given directly to the computer aspect than there is to control engineering.

There are five parts and twenty-three chapters which are divided as follows:

Introduction to Digital Programmed Systems. There are five chapters in this section which introduce typical problems, block diagrams of machines and logical building bricks. This is followed by a description of various types of coding and the fundamentals of programming. The last chapter in this section discusses more advanced concepts such as interpretive and compiling routines with finally a section on ALGOL.

Functional Approach to Systems Design. This part has four chapters. The first discusses various methods of numerical analysis. The second chapter discusses special systems required for the operations of searching, sorting, ordering, and modifying. The next introduces such special purpose machines as the digital differential analyser, real time computers for control and business and a logistics computer. The last chapter in this section introduces a feature which makes this book unique. A complete computer given the name PEDAGAC is described at various points throughout the book with full circuit diagrams and wiring schedules and this to the engineer new to the subject foms a thread throughout the remainder of the book. This chapter specifies the machine.

Foundations for the logical design of digital circuitry. This part has five chapters and deals exhaustively with Boolean algebra and matrices.

Logical design of digital computer circuitry. Here we have discussed the units required for addition, subtraction, multiplication and division in both their serial and parallel forms. Then follows a chapter on control. The last chapter gives detail of the logical design of the PEDAGAC.

Electronic design of digital circuitry. This part has five chapters dealing with such features as synchronization and reliability. One chapter is devoted to semi-conductor devices and another to magnetic elements such as ferrite cores, cryotrons, etc. A chapter discusses the various methods of storage, drums, cores magnetic film, and also certain output and input devices. The last chapter is concerned with completing the information on the PEDAGAC.

This book contains a vast amount of information and the importance of describing the development of the PEDAGAC at its various stages cannot be over emphasized and also the text is everywhere accompanied by very fine diagrams.

C. C. RITCHIE.

BOOK REVIEWS PUBLISHED IN OTHER INSTITUTE AND SOCIETY PERIODICALS

It is proposed to publish, approximately quarterly, the titles of books reviewed in the Institute and Society's other periodicals.

PROCEEDINGS OF THE PHYSICAL SOCIETY

(Vol. 77, May 1, 1961)

Non-relativistic Quantum Mechanics, by R. M. Sillitto.
Some Mathematical Methods of Physics, by G. Goertzel and N. Tralli.
Diffraction. Structure des Images, Volume 2 of *Traité d'Optique Instrumentale*, by A. Maréchal and M. Françon.
High Speed Aerodynamics and Jet Propulsion, Volume 5, *Turbulent Flows and Heat Transfer*, edited by C. C. Lin.
The International Encyclopedia of Physical Chemistry and Chemistry Physics, Volume 1, *Elements of the Kinetic Theory of Gases*, by E. A. Guggenheim.
Numerical Methods for High Speed Computers, by G. N. Lance.
Translation from Russian for Scientists, by C. R. Buxton and H. S. Jackson.
Fourier Analysis and Generalized Functions, Students' Edition, by M. J. Lighthill.
University Physics, by F. C. Champion.
Handbuch der Physik, Volume 12, *Thermodynamik der Gase*, edited by S. Flügge.
Travaux Pratiques de Physique Nucléaire et de Radiochemie, by M. Duquesne, R. Grégoire and M. Lefort.

(Vol. 78, July 1, 1961)

Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Volumes I and II, edited by N. R. Nilsson.
Nuclear Spectroscopy, edited by Fay Ajzenberg-Selove.
Review of Non-linear Wave Mechanics, by L. De Broglie.
Laboratory Handbook of Toxic Agents, by C. H. Gray.
Quantum Electronics, edited by C. H. Townes.
Annual Review in Automatic Programming, Volume 1, edited by R. Goodman.
Crystal Growth, Discussions of the Faraday Society, No. 5, 1949.
Growth of Crystals. Volume 1. *Reports at First Conference on Crystal Growth*, held at the Institute of Crystallography, Moscow, March 1956. Volume 2. *Interim Reports between First and Second Conferences of Crystal Growth*. Edited by A. V. Shubnikov and N. N. Sheftal.
Encyclopedia of Physics, Volume IX, *Fluid Dynamics*, Volume III, edited by S. Flügge.
The Interpretation of X-ray Diffraction Photographs, 2nd Edn., by N. F. M. Henry, H. Lipson and W. A. Wooster.
Theoretical and Experimental Physics, by H. G. Jerrard and D. B. McNeill.

JOURNAL OF SCIENTIFIC INSTRUMENTS

(Vol. 38, May, 1961)

Tables Related to Radiation Emerging from a Planetary Atmosphere with Rayleigh Scattering, by K. L. Coulson, J. V. Dave and Z. Sekera.

The Electro-Erosion Machining of Metals, by A. L. Livshits.

(Vol. 38, July, 1961)

The Electron Microscope: The Present State of the Art, by M. E. Haine with a chapter in collaboration with V. E. Cosslett.

BRITISH JOURNAL OF APPLIED PHYSICS

(Vol. 12, May, 1961)

Elektronische Hilfsmittel des Physikers, by W. Gruhle.

Modern University Physics, by J. A. Richards, F. W. Sears, M. R. Wehr and M. W. Zemansky.

(Vol. 12, June 1961)

Moderne Messmethoden der Physik: Teil I Mechanik und Akustik, by F. X. Eder.

Proceedings of the 1960 *Heat Transfer and Fluid Mechanics Institute*, edited by D. M. Mason, W. C. Reynolds and W. G. Vincenti.

Proceedings of the Radioactivation Analysis Symposium held in Vienna in 1959. Presented by the International Atomic Energy Agency Joint Commission on Applied Radioactivity.

Fortschritte der Hochfrequenztechnik, edited by J. Zenneck, M. Strutt and F. Vilbig.

Carbon: Proceedings of the Fourth Conference held at the University of Buffalo, New York.

Semiconductor Technology, edited by G. K. T. Conn.

(Vol. 12, July 1961)

Digital Computers and Nuclear Reactor Calculations, by W. C. Sangren.

Histological Techniques for Electron Microscopy, by D. C. Pease.

Magnetic Materials, by F. Brailsford.

Forthcoming Institute and Society Meetings

Date	*Place*	*Speaker*	*Title and other details*	*Time*	*Branch or Group*
Sept. 18	**Cambridge**		Visit to Tube Investments Research Laboratories The visit is strictly limited and registration is necessary.		Stress Analysis
Sept. 18	**Manchester** College of Science and Technology	Dr. L. R. G. Treloar, F.Inst.P. (*Shirley Institute, Manchester*)	**A physicist's view of long chain molecules.** (Branch Chairman's address).	6.30 p.m.	Manchester and District
Sept. 19	**London** Royal Institution of Great Britain		Simon Memorial Lecture	4 p.m.	Low Temperature
Sept. 20 to 22	**Shrivenham** Royal Military College of Science		Symposium on **Some aspects of the physics of space research** Registration is necessary		
Sept. 20 to 22	**Llandudno**		Conference on Rheological techniques Registration for this conference is necessary. Programs and application forms are available from Dr. P. Lord, A.Inst.P., Royal Technical College, Peel Park, Salford, 5.		Non-Destructive jointly with the British Society of Rheology
Sept. 21	**Bangor** University College North Wales	Dr. D. Shoenberg, F.R.S. (*University of Cambridge*)	The Guthrie Lecture of the Institute and Society on **The de Haas-van Alphen effect and the electronic structure of metals**	4.30 p.m.	
Sept. 21 and 22	**Bangor** University College of North Wales		Conference on **Radiospectroscopy of solids** Registration is necessary		
Sept. 23	**Durham**		Summer meeting and visits to new Departments of Pure and Applied Physics, Organ Factory and Museum of Oriental Art The visits are limited and registration is necessary		North Eastern
Sept. 26	**Glasgow** The University	Professor N. F. Mott, F.Inst.P., F.R.S. (*University of Cambridge*)	**The nature of the bond in metals and alloys**	7.15 p.m.	Scottish
Sept. 28 and 29	**Leamington Spa** Town Hall		Conference on **The physics of gas discharge devices** Registration is necessary		Electronics

The Register

ELECTIONS TO MEMBERSHIP

THE FOLLOWING ELECTIONS WERE MADE BY THE COUNCIL ON JULY 4, 1961

FELLOWSHIP of The Institute of Physics (12)

(a) Transferred from Associateship of The Institute of Physics

Beattie, John Reginald, B.Sc., Physicist, Pilkington Brothers Ltd., St. Helens, Lancs.

Cockburn, Sir Robert, M.Sc., Ph.D., Chief Scientist, Ministry of Aviation, London.

Hunter, Arthur Norman, B.Sc., Ph.D., Professor of Physics, Royal College, Nairobi.

Mason, Peter, M.Sc., Ph.D., Principal Physicist, Natural Rubber Producer's Research Association, Welwyn Garden City, Herts.

Qurashi, Mazhar Mahmood, M.Sc., Ph.D., Principal Scientific Officer, Central Laboratories, Council of Scientific and Industrial Research, Karachi, India.

Rhoderick, Emlyn Huw, M.A., Ph.D., Senior Principal Scientific Officer, Services Electronics Research Laboratory (Admiralty), Baldock, Herts.

Spicer, Brian Milton, M.Sc., Ph.D., Senior Lecturer, University of Melbourne, Australia.

Zussman, Jack, M.A., Ph.D., Senior Lecturer in Geology, University of Manchester.

(b) Other Elections

Alexander, Dorothy Jessie, B.Sc., M.A., Staff Inspector for Science, L.C.C., London.

Cooper, Robert Ion Beverley, M.A., Ph.D., Head of Transistor Controls Dept., Standard Telephone and Cables Ltd., Footscray, Kent.

Fry, Thomas Maxwell, B.A., Chief Physicist, U.K. Atomic Energy Authority, Atomic Energy Establishment, Winfrith, Dorset.

Merrison, Alexander Walter, B.Sc., Ph.D., Professor of Experimental Physics, University of Liverpool.

ASSOCIATESHIP of The Institute of Physics (45)

(a) Transferred from Graduateship of The Institute of Physics

Barrett, Paul Robert, M.Sc., Ph.D., Physicist, English Electric Co. Ltd., Leicester.

Bland, William Frank, B.Sc., Physicist, U.K. Atomic Energy Authority, Thurso, Caithness, Scotland.

Cunningham, Frederick Paulinus, M.A., Senior Science Master, Douai School, Woolhampton, Berks.

Duggan, Michael John, B.Sc., Scientist, Medical Research Council (Radiological Protection Service), Sutton, Surrey.

Goddard, Brian Anthony, B.Sc., Senior Physicist, Birmingham Group of Hospitals.

Goldfinch, Edward Peter, M.Sc., Group Leader, H.M. Hobson Ltd., Wolverhampton.

Harrison, Eluned, B.Sc., Assistant Lecturer, Oxford College of Technology.

Henderson, John, B.Sc., Senior Scientific Officer, National Engineering Laboratory, D.S.I.R., East Kilbride, Scotland.

Holmes, Ernest Leonard, M.A.Sc., Ph.D., Lecturer and Research Associate, University of Toronto, Canada.

Parker, David Alec, B.Sc., A.R.C.S., Group Leader, Associated Electrical Industries (Rugby) Ltd., Rugby, Warks.

Phillips, Michael, B.Sc., Scientific Staff, The General Electric Co. Ltd., Hirst Research Centre, Wembley, Middx.

Pullen, John, B.A., Research Assistant, Electrical Research Association, Leatherhead, Surrey.

Ryder, Edward Alexander, B.Sc., Control Engineer, Hawker Siddeley Nuclear Power Co. Ltd., Bucks.

Sanders, Arthur Joseph, B.Sc., Technical Officer, British Nylon Spinners Ltd., Pontypool, Mon.

Stacey, Arthur James, B.Sc., Physicist, The Institute of Cancer Research, Royal Cancer Hospital, London.

Staines, Alan Edward Cook, B.Sc., Geophysicist, British Petroleum Co. Ltd., London.

Synge, Michael John, B.A., Physicist, Atomic Power Constructions Ltd., London.

Teh, Hock Heng, M.Sc., Assistant Lecturer, University of Malaya, Kuala Lumpur, Malaya.

Thomas, Dewi Gwynfa Bailey, B.Sc., A.R.C.S., Senior Research Officer, Cotton, Silk and Man Made Fibre Research Association, Shirley Institute, Didsbury, Manchester.

(b) Transferred from Fellowship of The Physical Society

Dixon, Francis Alfred, M.Sc., Higher Scientific Officer, Weapons Research Establishment, Salisbury, S. Australia.

Harris, Norman Duncan Campany, M.Sc., Physics Master, King Edwards School, Birmingham.

Loftus, Peter, M.A., Head of Reliability Assessment Group, A. V. Roe & Co. Ltd., Cheshire.

Thiele, Alan Philip Craven, B.Sc., Group Leader, Cossor Radar and Electronics Ltd., Harlow, Essex.

(c) Transferred from Student of the Institute and Society

Franklin, Rauoul Norman, M.Sc., D.Phil., Senior Research Fellow, Royal Military College of Science, Shrivenham, Wilts.

Rajagopal, Erode Subramanian, M.A., M.Sc., Ph.D., Senior Research Fellow, Indian Institute of Science, Bangalore.

Scott, John Terence, M.Sc., Research Assistant, University College, London.

(d) Other Elections

Allbright, Graham Scott, B.Sc., Assistant to Chief Physicist, Ozalid Co. Ltd., Loughton, Essex.

Blackburn, David Alexander, B.Sc., Assistant, University of Edinburgh.

Brain, Douglas Harold, M.A., Senior Physicist, J. & P. Coats Ltd., Paisley, Renfrewshire, Scotland.

Brown, David Scatcherd, B.A., Physicist, Sir Howard Grubb-Parsons & Co. Ltd., Newcastle-upon-Tyne, Durham.

Curtis, Leon Maurice, M.Sc., Plant Manager, U.K. Atomic Energy Authority, Capenhurst, Chester.

Durrani, Saeed Akhtar, M.Sc., Ph.D., Senior Scientific Officer, U.K. Atomic Energy Authority, Atomic Energy Establishment, Winfrith, Dorset.

Everingham, Ian Bouchier, B.Sc., Geophysicist, Bureau of Mineral Resources, W. Australia.

Floyd, Kenneth Lewthwaite, M.A., Senior Research Physicist, British-Enka Ltd., Aintree, Liverpool.

Greenaway, David Leslie, B.Sc., Ph.D., Research Physicist, Standard Telecommunication Laboratories Ltd., Harlow, Essex.

Hansen, Norman Reginald, M.Sc., Senior Lecturer, University of N.S.W., Australia.

Hurd, David Leonard, B.Sc., Assistant Lecturer, Bedford College, University of London.

Lloyd, John Lyttleton, B.Sc., Ph.D., Lecturer, Brighton Technical College, Sussex.

Matthews, John, B.Sc., Scientific Officer, National Institute of Agricultural Engineering, Silsoe, Beds.

Nicholls, George Robert, B.Sc., Deputy Headmaster, Central Technical School, Sheffield, Yorks.

Painter, Gerald Hayes, M.Sc., School Master, Physics Department, Giggleswick School, Settle, Yorks.

Sanders, Herbert Ralph, B.Sc., Experimental Officer, Department of Scientific and Industrial Research, Torry Research Station, Aberdeen, Scotland.

Silva, Michael Ashmore, B.Sc., Physicist, Aeon Laboratories, Egham, Surrey.

Turner, John Stewart, M.Sc., Ph.D., Research Officer, C.S.I.R.O., N.S.W., Australia.

Wilson, Norman, B.Sc., Scientific Officer, British Cotton Silk and Man Made Fibres Research Association, Shirley Institute, Didsbury, Manchester.

GRADUATESHIP of The Institute of Physics (45)

(a) Transferred from Student of the Institute and Society

Ashley, Derek George, Dip.Tech., Research Assistant, G.K.N. Group Research Laboratory, Wolverhampton.

Bagot, Charles Hervey, B.Sc., Research Student, University of Adelaide, Australia.

Chamberlain, Fred, Dip.Tech., Student Apprentice, English Electric Co. Ltd., Stafford.

Cox, Barrie Basil, Dip.Tech., Assistant Experimental Officer, Royal Radar Establishment, Malvern, Worcs.

Cozens, John Ritchie, B.Sc., Research Student, University of Exeter.

Ince, John, Dip.Tech., Physicist, Dunlop Rubber Co. Ltd., Birmingham.

Jenkin, John Grenfell, B.Sc., Research Student, Australian National University, Canberra, Australia.

Matthew, Evelyn Maime, B.Sc., Research Student, University of Queensland, Australia.

Moppett, David John, Dip.Tech., Research Physicist, Gas Council, Midlands Research Station, Solihull, Warks.

Nelson, Richard Stuart, B.Sc., Scientific Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Strong, Edward Russell, B.Sc., Group Leader, Handley Page Ltd., St. Albans, Herts.

Williams, Gwynn Rees, B.Sc., Operations Analyst, Canadian International Paper Co., Montreal, Canada.

(b) Other Elections

Bates, Brian, M.Sc., Research Scientist, Associated Electrical Industries Ltd., Harlow, Essex.

Best, Philip Ernest, B.Sc., Research Student, University of Western Australia.

Branwood, Alfred, B.Sc., Research Student, University College of North Wales, Bangor.

Carter, Peter, B.Sc., Research Student, University of Leeds.

Churchill, Rowland Edwin, B.Sc., Transistor Development Engineer, Standard Telephone and Cables Ltd., Footscray, Kent.

Clarke, John Alfred, M.Sc., Optical Designer, C. Baker (Instruments) Ltd., Croydon, Surrey.

Collinson, Brian, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Windscale Works, Seascale, Cumb.

Crossland, Bryn, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Capenhurst, Chester.

Dart, Roy Elstone, B.Sc., Instructor, Royal Air Force Technical College, Henlow, Beds.

Dimond, Richard Kevin, B.Sc., Research Student, University of Western Australia.

Edwards, John Eifion, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Risley, Lancs.

Geissler, Erik, B.Sc., Research Student, Clarendon Laboratory, Oxford.

Gurr, Graham Edward, B.Sc., Senior Research Scholar, University of Adelaide, S. Australia.

Hall, Sydney Reading, B.Sc., Research Student, University of Western Australia.

Hampson, Philip, B.Sc., Experimental Officer, Imperial Chemical Industries Ltd., Blackley.

Horn, David Roger, B.Sc., Technical Assistant, Hilger & Watts Ltd., London.

Jones, Hugh Gwynfryn, B.Sc., Assistant Experimental Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Kemeny, Andrew, Physicist, British Oxygen Ltd., Morden, Surrey.

Lawn, Brian Ronald, B.Sc., Research Student, University of Western Australia.

Marlor, Guy Anthony, B.Sc., Research Assistant, University of Durham.

Martin, Charles Herbert, B.Sc., Physicist, Nuclear Power Plant Co. Ltd., Knutsford, Cheshire.

Nicholas, Keith Harlow, B.Sc., Research Student, University of Durham.

Royce, Victor Keith, B.Sc., Assistant Editor, Physics Abstracts, Institute of Electrical Engineers, London.

Norbury, Joseph Frederick, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Windscale Works, Seascale, Cumb.

Oliphant, Michael John, B.Sc., Experimental Officer, Weapons Research Establishment, Salisbury, S. Australia.

Parkes, Alan Ernald, B.Sc., Section Leader, Joseph Lucas (Gas Turbine Equipment) Ltd., Birmingham.

Pipes, Michael John, B.A., Physics Master, Lord Weymouth's School, Warminster, Wilts.

Pritchard, Michael David William, B.Sc., Assistant Lecturer, Building Science Department, Guildford County Technical College, Surrey.

Richards, Donald Stanley, B.Sc., Research Assistant, Regent Street Polytechnic, London.

Riley, Glen Haxton, B.Sc., Research Student, University of Western Australia.

Rogers, Colin Brian, B.Sc., Engineer, The Plessey Co. Ltd., Ilford, Essex.

Spargo, Alan Edwin Charles, B.Sc., Research Student, University of Western Australia.

Williams, Gwilym Howard, B.Sc., A.R.C.S., Assistant Experimental Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

FELLOWSHIP of The Physical Society (14)

(*a*) *Transferred from Student of the Institute and Society*

Howard, Roger, B.Sc., Ph.D., Instructor, University of British Columbia, Canada.

Hurrell, John Patrick, B.A., Research Student, Clarendon Laboratory, Oxford.

Sandiford, David John, M.Sc., M.A., Ph.D., Instructor, Yale University.

(*b*) *Other Elections*

Booth, Norman, B.Sc., Ph.D., Chief Executive, British Oxygen Ltd., Morden, Surrey.

Boyle, Alan John Fraser, B.Sc., Ph.D., Lecturer, University of Manchester.

Brdicka, Miroslav, Professor of theoretical physics, Charles University, Prague.

Hall, Henry Edgar, B.A., Ph.D., Professor of Physics, University of Manchester.

Hall, Timothy Peter Prendergast, M.Sc., Research Student, Clarendon Laboratory, Oxford.

Isenberg, Cyril, B.Sc., Research Student, King's College, University of London.

Jackson, Edward Thomas, B.Sc., Inspector of Technical Schools, Education Department, Victoria, Australia.

Miller, Donald Bowie, B.Sc., Research Student, University of Glasgow.

O'Brien, Mary Clare Milward, B.A., D.Phil., Fellow and Tutor, Lady Margaret Hall, Oxford.

Richards, Elfyn John, O.B.E., M.A., D.Sc., Professor of Aeronautical Engineering, University of Southampton.

Suffczynski, Macief, M.Sc., Ph.D., Department of Theoretical Physics, University of Warsaw.

21 Students and 4 Subscribers were also admitted.

Manuscripts accepted for publication in the Institute and Society's periodicals

British Journal of Applied Physics

Spectral response of antimony-caesium photocathodes. By J. B. Birks and I. H. Munro.

Measurements have been made of the relative photoelectric quantum efficiency $\eta(\lambda)$ of $SbCs_3$ cathodes of photomultipliers with Pyrex and quartz windows, from $\lambda = 200$–650 mμ. $\eta(\lambda)$ depends on the window transmittance $W(\lambda)$, the cathode absorbance $A(\lambda, d)$, the absolute photoelectric quantum efficiency $Q_a(\lambda)$ and the photoelectron escape probability $f(\lambda, d)$. Comparison with other data has allowed the separation of these factors, yielding *inter alia* the absorption spectrum of $SbCs_3$ down to $\lambda = 220$ mμ and the absolute photoelectric threshold curve $Q_a(\lambda)$ plotted against λ. The optimum thickness for a thin cathode is $d = 200$Å. Errors in other published data are noted, and methods of increasing $\eta(\lambda)$ and of improving scintillation detectors are discussed.

Estimation of the total emission of a diode under normal operating conditions without removing the space charge. By C. S. Bull and R. K. Fitch.

The total emission of the cathode of a planar diode over a range of cathode temperatures has been measured in a non-destructive way by making a detailed examination of the characteristics. A total emission of about 25 a/cm² has been found for an EA 50 operating at normal cathode temperatures. This result has been tested by comparing theoretical values of the space-charge smoothing factor calculated from the characteristic curves in two distinct ways, only one of which involves the total emission directly.

It was found that Richardson's equation for the total emission fails noticeably over the wide range of cathode temperatures investigated, and that this failure is not explicable on the basis of changes in the cathode work-function.

Some problems in the development of a commercial thermoelectric refrigerator. By T. B. Burnett, H. O. Lorch, and J. E. Thompson.

Two basic problems in the development of a thermoelectric refrigerator are the construction of a cooling unit, consisting of the thermoelectric junctions, and the optimization of the complete refrigerator design to make best use of the thermoelectric material. It is essential for the unit to achieve good thermal contact with the cooling chamber and to have good electrical contact across the p and n semiconductor bars forming each junction. A simple but accurate method of measuring the junction resistance is shown, and the relative merits of various methods of forming the cooling unit are discussed. The heat balance equations of a refrigerator are given which include the cooling fin system and the method of optimization of the design is noted.

Clean glass substrates for permalloy films. By A. F. Fray and S. Nielsen.

Possible defects on glass surfaces, and methods of detecting and reducing them, are discussed. A correlation between the state of the surface and the magnetic properties of permalloy films is observed. Best results were obtained on surfaces obtained by quenching molten vacuum-melted glass.

Physics of the tunnel diode. By A. K. Jonscher.

A brief account is given of the physical principles governing the operation of tunnel diodes. The material parameters affecting the peak and valley currents and the capacitance are discussed. The significance of some low temperature phenomena is explained.

Magnetism in transition metal alloys. By W. M. Lomer.

The electronic structure of alloys involving transition elements is complex, but recent studies by various techniques allow us to discuss the range of validity of certain simple concepts. This paper emphasizes the domain of validity of the idea of a local atomic spin and points out that the collapse of this model is associated with the lifetime of the spins. When the lifetime becomes very short the model is entirely inappropriate. It appears, however, to apply to the metals Cr, Mn, Fe, Co, Ni and to their alloys with many simple metals.

Hypothesis on the ionic mechanism of the growth of whiskers obtained by reduction of the metal halides. By J. Mazur and J. Rafalowicz.

On the basis of experimental results the authors put forward the hypothesis of the existence of an ionic mechanism of whisker growth side by side with a non-ionic (atomic or molecular) mechanism.

The ionic concentration calculated from the current density is of the order of 10^{12} ions/cm³ at 650°c and therefore the possibility of an ionic mechanism of whisker growth cannot be excluded; this conclusion is reinforced by the observed velocity of growth of copper whiskers, and the influence exerted on this growth by an electric field. These preliminary measurements and qualitative observations make the simultaneous co-existence of the two growth mechanisms an acceptable hypothesis.

Diamond knife ultra microtomy of metals and the structure of microtomed sections. By R. Phillips.

The parameters of microtome sectioning are defined, and the use of the diamond knife ultra microtome for metallurgical studies is described. The effect of cutting stresses on the formation of sections is discussed. It is reasoned that vibration of parts of the cutting system would only be excited by the first impact of the specimen or the knife and not by the forces acting on them throughout cutting. Vibration is shown to produce smooth variations in section thickness, the thickness being constant all along any normal to the direction of cutting, and varying along the direction of cutting. Knife marks are shown to be due to variations in cutting stress associated with knife edge defects; these produce variations in the thickness and structure of the section, even when the mechanism proposed by Farrant cannot apply. Some folds and wrinkles are explained as being due to variation in cutting stress due to variations in knife edge quality. All the above defects can be avoided by a proper choice of experimental conditions, but it is shown that there is a shear stress imposed on the section during cutting which in the majority of cases permanently deforms it, producing a surface structure characteristic of the material being cut.

Measurement of the dielectric constant of filament nylon in a transverse field. By F. S. Ward.

An instrument has been designed for measuring the dielectric constant of a material in the form of a single cylindrical filament, and experiments are described in which it is used for measurements on nylon. The filament is placed centrally between two silvered optical flats, which form a parallel-plate condenser and serve as the tuning condenser of a radio-frequency oscillator. According to an existing theory, the change in capacity due to the presence of the dielectric is given by

$$\delta C = \frac{b^2}{2} \frac{H}{D^3} \cdot \tanh \frac{\pi B}{2 D} \Big/ \left(\frac{\varepsilon + 1}{\varepsilon - 1} - \frac{\pi^2 b^2}{3 D^2} \right)$$

(where b is the radius of the filament, H the length of the condenser, B the width and D the distance between the plates) and δC can be determined from the corresponding change in oscillator frequency, if the electrical parameters of the circuit are known. The experimental observations confirmed the general form of the equation, but they were not sufficiently accurate to verify the second-order term $\pi^2 b^2/3 D^2$. A value of 3·0 was found for the dielectric constant of nylon at 6 to 7 Mc/s, which is in reasonable agreement with values of 3·1 to 3·4 recorded by other workers for both filament and bulk nylon.

Journal of Scientific Instruments

Measurement of the figure of merit of a thermoelectric material. By A. E. Bowley, L. E. J. Cowles, G. J. Williams and H. J. Goldsmid.

A description is given of a single piece of apparatus for measuring the three parameters which are involved in the figure of merit of a thermoelectric material. This apparatus uses only direct current and is based on Harman's technique in which a temperature gradient is established by means of the Peltier effect. It is demonstrated that the corrections for radiative heat transfer take a relatively simple form at room temperature.

It is also shown that the figure of merit of a thermo-electric material can be obtained by measuring the maximum lowering of temperature using the Peltier effect in a junction between the sample under test and a metal.

Systematic operational testing of the von Eller optical synthesis machine. By J. C. Coppola.

The von Eller optical synthesis machine gives the photographic sum of a large number of terms of a Fourier series. Several critically located components on the instrument can easily get out of adjustment, simply through normal use. A procedure is described for taking three photographs to define that part of the instrument in need of adjustment and the amount of correction necessary.

Simple viscometer for use with low melting point metals. By D. M. Cottingham.

The text describes a viscometer suitable for making relative measurements over a wide range of viscosities and over a temperature range of 20°c to 600°c. The viscometer is calibrated with standard liquids and has been designed particularly for low melting point metals. It should also be suitable for use with organic liquids. The operating techniques and sources of error are discussed. An empirical equation relating viscosity to the variable parameters is given and results of experiments on lead are included.

Magnetic crack detector. By P. H. Dawson.

When using a gear simulation disk machine to perform experiments on pitting it is often desirable that pits or the cracks that precede pits should be detected at the earliest moment after their formation, if possible while the disk is rotating. A method for doing this, using a magnetic detector in the form of a tape recorder head, is described. The technique is also applicable to the detection of cracks in other components such as Wohler fatigue specimens.

Humidity-control device for the Buerger precession camera. By J. R. Einstein.

A device has been designed and built to maintain a crystal in equilibrium with an atmosphere of constant relative humidity during x-ray photography with the Buerger precession camera. The device employs a small constant-temperature enclosure, mounted directly on the goniometer head of the camera. A resistance-wire winding is used to supply a small amount of heat to the enclosure. The temperature is maintained constant by a thermistor-controlled electronic circuit. Temperature control is not interrupted during adjustments to the goniometer head nor when the film is changed.

Recording refractometer for measuring refractive indices of optical glasses over a wide range of wavelengths. By M. J. C. Flude, K. J. Habell and A. Jackson.

A description is given of a spectrometer on which refractive indices of prismatic specimens have been measured from the near ultra-violet to the near infra-red. The relationships between accuracy of measurement and tolerance on angle measurement and wavelength are considered. Values of refractive index for six optical glasses are quoted for the wavelength range 366 mμ to 2300 mμ with an estimated accuracy to ±0·00003 or better.

Anti-distortion mountings for instruments and apparatus. By R. E. Jones.

Some principles for the mounting of instrument platforms are discussed. For many optical and mechanical instruments, the working platform may best be protected from external mechanical distortion by supporting or suspending the platform by members, usually three, whose stiffness is much less than that of the platform. At the same time, these members can be stiff enough to give a fairly rigid location. Some possible arrangements are outlined.

High pressure hydrogen gas target. By J. Kirk.

A description is given of a hydrogen gas target, which has been designed to operate at a pressure of 450 lb/in² and at a temperature of −70°c, to be used in studies of x-ray scattering from hydrogen, using a nuclear photographic emulsion technique. The choice of material for the entrance window and the high pressure sealing of flanges is discussed.

Proceedings of The Physical Society

On the change of activation energy with impurity concentration in semiconductors. By J. F. Barnes and R. H. Tredgold.

The existing theories of change of activation energy with impurity concentration are discussed and their limitations pointed out. The ionization energy of a pair of impurities in a dielectric medium is calculated as a function of impurity separation. Assuming a random distribution of impurities, an averaging process is employed to calculate the mean change in activation energy with concentration. This approximation should be poor for high impurity densities but for low densities leads to satisfactory agreement with experiment.

Magnetic resonance in the nitrogen afterglow. By J. M. Anderson and J. N. Barry.

The decay of a magnetic resonance absorption in the nitrogen afterglow has been followed and compared with the decay of the afterglow itself. Afterglow was never, in any case, obtained without the presence of this absorption and vice versa. Simultaneous records of the two quantities showed that in all cases the absorption disappeared logarithmically at a rate which did not increase with nitrogen pressure while the afterglow intensity decayed according to an $I^{-1/2}$ law in a somewhat longer time. The rates of both processes are increased by addition of oxygen. The processes involved seem quite independent. It seems possible that the particle responsible for the absorption and destroyed by oxygen is identical with that responsible by a bimolecular process for the later stages of the afterglow in oxygen-free nitrogen.

The depolarization of negative muons in light elements. By A. Astbury, F. M. Hattersley, M. Husain, M. A. R. Kemp, H. Muirhead and T. Woodhead.

A measurement of the polarization retained by negative muons in light elements is described. For elements with spin 0 the muon is found to retain about 17% of its initial polarization.

A measurement of the total cross section for the production of neutral pions in proton-proton collisions at 383 mev. By A. Astbury, M. A. R. Kemp, H. Muirhead, R. G. P. Voss and T. Woodhead.

A value of (59 ± 9) μbn has been obtained for the total cross section for the production of π^0-mesons in proton-proton collisions at 383 mev.

Capture rates for negative muons in light elements. By A. Astbury I. M. Blair, M. Husain, M. A. R. Kemp and H. Muirhead.

Measurements are reported on the capture rates of negative muons in certain light elements. Agreement with other experimental data is found, but a large discrepancy between the calculated and experimental values of the capture rate in fluorine is noted.

The radiative capture cross section of ^{238}U for neutrons in the energy range 0·37 to 4·0 mev. By J. F. Barry, J. L. Bunce and J. L. Perkin.

The cross section of the reaction ^{238}U (n, γ) ^{239}U has been measured for neutrons in the energy range 0·3 to 4·0 mev using an activation method. Fission products in the irradiated samples were removed chemically and the ^{239}U produced was determined by counting the γ-ray activity with a sodium iodide scintillation spectrometer. The cross section was found to increase from about 300 mbn at 0·3 mev to about 400 mbn at 1·1 mev. It then fell sharply to some 30 mbn at 4 mev.

The shape of the excitation function for this reaction is typical of that found for other heavy even–even nuclides far from a closed shell. It is due to the competition between the radiative capture process and inelastic scattering from the similar collective level structures of these nuclides.

The band structure of body-centred cubic transition metals. By C. A. Bates and K. W. H. Stevens.

The theory of the magnetic properties of iron put forward by Mott and Stevens made a number of assumptions about the band structures of the

body-centred cubic 3d transition metals. The purpose of the present paper is to give an account of a theoretical study which has been made to see what could reasonably be expected on fairly general grounds about the band structures. It then becomes possible to see more clearly what innovations are required for the Mott and Stevens theory. The method used is essentially a tight binding method, with the feature that the functions used are not located at lattice sites but are on the links joining nearest neighbour lattice points. It leads to an 8×8 matrix for the lattice potential for each value of $\mathbf{k}$. A discussion of the diagonalization of this 8×8 matrix is given for a number of symmetry points and directions in k-space, and it is shown that a good deal of valuable information can be obtained from relatively simple ideas. It is also shown that the band structure so obtained is incomplete because two of the d-functions are omitted, and these are then included by perturbation methods. The Mott and Stevens model of iron is shown to follow from assumptions about the results of this perturbation treatment. A discussion is given of the ground state determinantal functions for vanadium, chromium and iron which it is hoped will be of use in interpreting the physical properties of these elements. Apart from the value the theory may have in its application to the above metals, the algebraic treatment provides an elegant example of the effects of symmetry on band structures, previously thoroughly discussed in terms of groups by Bouckaert, Smoluchowski and Wigner.

A low temperature adiabatic calorimeter for condensed substances. Thermodynamic properties of argon. By P. Flubacher, A. J. Leadbetter and J. A. Morrison.

An adiabatic calorimeter has been constructed for the study of properties of condensed substances in the temperature range 2° to 300°K. Two resistance thermometers were used, one of platinum for $T > 11$°K and one of carbon for $T < 11$°K. The carbon thermometer was calibrated on the thermodynamic temperature scale by using the calorimeter vessel as a gas thermometer; subsequent absolute shifts of its resistance on cycling between room temperature and liquid helium temperatures were taken into account by calibrations against the platinum thermometer.

The heat capacities of solid and liquid argon have been measured between 2° and 86°K with estimated accuracies of $\pm 2\%$ at the lowest temperatures, increasing to $\pm 0{\cdot}2\%$ for $T > 20$°K but decreasing to $\pm 0{\cdot}5\%$ at the highest temperatures. In conjunction with these measurements, vapour pressures were measured in the temperature range 66° to 86°K.

The heat of fusion was found to be $284{\cdot}5 \pm 0{\cdot}4$ cal mole^{-1}, the triple point temperature $83{\cdot}810$°K and the triple point pressure $0{\cdot}86 \pm 0{\cdot}02$ mm Hg. The amount of impurity in the specimen of argon was estimated to be 3 p.p.m. from a study of the melting range.

Direct measurement of the heat of vaporization of the liquid gave the result $1563{\cdot}6 \pm 4{\cdot}6$ cal mole^{-1} at $85{\cdot}67$°K, which corresponds to $1555{\cdot}0 \pm 4{\cdot}6$ cal mole^{-1} at the normal boiling point.

Thermodynamic properties of krypton. Vibrational and other properties of solid argon and solid krypton. By R. H. Beaumont, H. Chihara and J. A. Morrison.

The calorimetric methods described in the paper by Flubacher, Leadbetter and Morrison have been used to measure thermodynamic properties of solid and liquid krypton. Besides heat capacities and vapour pressures over a range of temperatures, the following were determined: heat of fusion $= 392{\cdot}0 \pm 2{\cdot}3$ cal mole^{-1}, T(tr.pt.) $= 115{\cdot}77$°K, p(tr.pt.) $= 548{\cdot}7 \pm 0{\cdot}1$ mm, heat of vaporization at $116{\cdot}85$°K $= 2179{\cdot}2 \pm 0{\cdot}9$ cal mole^{-1} and at the normal boiling point $= 2162 \pm 1$ cal mole^{-1}.

A number of properties of solid argon and solid krypton has been derived, in particular, the apparent Debye characteristic temperatures at 0°K and as a function of temperature, the heats of sublimation at 0°K, the static lattice energies and the zero point energies. The results of the thermal measurements on the solids have been correlated with expansivity and compressibility results and certain inconsistencies resolved. The calorimetric results are shown to be internally consistent.

The shapes of curves of $\Theta_D(T)$ against temperature indicate that anharmonic contributions to the vibrational properties of solid argon and solid krypton are appreciable, particularly in the region $T > \Theta_D/10$.

In the region below the melting points, C_p for both argon and krypton increases rather rapidly with temperature. This is interpreted as an effect of formation of vacancies in the solids. Enthalpies of formation are found to be 1280 ± 130 cal mole^{-1} for argon and 1770 ± 220 cal mole^{-1} for krypton. These are about two thirds of values estimated from theory. An effect of vacancy formation may also be seen in the vapour pressures.

Radiation damage in well-oriented pyrolytic graphites. By L. C. F. Blackman, G. Saunders and A. R. Ubbelohde.

Graphite formed by cracking methane under various conditions has been exposed to neutron irradiation. Changes in electronic properties were measured (i) after radiation damage, (ii) after "mild" annealing around 470°c, and (iii) after "strong" annealing at 2200°c and above. Effects of radiation damage are proportionately greatest in specimens whose properties are initially nearest to those of ideal graphite. Some discrimination can be made between the types of disorder originally present, and the disorder added by irradiation.

Changes of thermoelectric power of graphite in the direction of the c axis show "latent" increases attributed to disorder frozen in until after mild annealing.

An investigation into the mechanism of self-quenching Geiger–Muller counters containing argon with small quantities of xenon, oxygen and nitrogen. By A. J. L. Collinson, I. C. Demetsopoullos and J. M. Zarzycki.

The time distribution of spurious pulses in counters with treated and untreated cathodes was studied by pulse interval analysis, and plateau characteristics, charge per pulse and Geiger threshold potential are plotted as functions of the xenon concentration. In all the counters investigated, the presence of a minimum threshold indicates an optimum xenon concentration of 3·5%. Measurements of the corona threshold with argon and argon–xenon filling mixtures show a pressure dependent increase in gas multiplication with addition of xenon. This increase in ionization is tentatively explained by the hypothesis of two-body collisions between xenon atoms and argon excited molecules leading to the formation of the molecular ion AXe^+. Mobilities obtained from transit time measurements identify the ions involved as A_2^+ (1·82 cm sec^{-1} per v cm^{-1}), possibly NO^+ (2·45 cm sec^{-1} per v cm^{-1}) this ion appearing after the counters have been in continuous discharge, and an ion of mobility 1·64 cm sec^{-1} per v cm^{-1} which is not inconsistent with the postulated AXe^+ molecular ion.

Electron correlation in the ground state of helium. By C. A. Coulson and A. H. Neilson.

Formulae are obtained for the distribution function $f(r_{12})$ of the inter-electronic distance r_{12} in the ground state of helium, and for the mean value of any positive integral power of r_{12}. Five different wave functions are considered, showing varying degrees of electron correlation. The greater the degree of correlation the larger is the mean electronic separation. Curves of $f(r_{12})$ are plotted, and from them the size and depth of the Coulomb hole are evaluated. There is a close correlation between the mean value of $1/r_{12}$ and the error in the energy as calculated with these five wave functions.

On perturbation calculations for the π-electrons and their application to bond length reconsiderations in aromatic hydrocarbons. By C. A. Coulson and A. Golebiewski.

An alternative method for calculating the atom–atom, atom–bond and bond–bond and other polarizabilities in π-electron molecules, originally due to R. D. Brown, is extended to deal with orbital degeneracy. It is then applied to a new discussion of the bond lengths in certain aromatic hydrocarbons. A simple and partly self-consistent method of calculation is developed, which yields results in satisfactory agreement with recent accurate experimental measurements.

Proton scattering by copper at 10 mev. By B. R. Easlea.

An optical model analysis is given of the experimental data of Hintz at 9·75 mev and of Greenlees *et al.* at 9·30 and 9·47 mev on the scattering of protons by natural copper. A sufficiently general form factor for the imaginary part W of the optical potential is used such that W can have a maximum value lying in any desired region of the nucleus. It is found that the absorption must be peaked at the surface of the nucleus in order to fit not only the polarization and differential elastic cross section, but at the same time to give the correct magnitude of the total reaction cross section. The available experimental data do not at present allow the determination of how much absorption occurs at the centre of the nucleus or whether the maximum of W should lie slightly beyond the half-way radius of the real part of the optical potential.

Vacuum ultra-violet spectra of multiply ionized inert gases. By B. C. Fawcett, B. B. Jones and R. Wilson.

The high temperature plasma ($kT_e \simeq 20$ ev) produced in ZETA is a copious source of spectral lines emitted by highly ionized atoms in the vacuum ultra-violet. Spectroscopic investigations in the wavelength range 400Å–1000Å have revealed several new lines due to the multiply ionized inert gases Ne, A, Kr and Xe. The method of identification is based on the successive appearance of the ionization states of each element, supplemented by isoelectronic calculations which also allowed transitions to be assigned to most lines.

The efficiency of production of characteristic x-radiation in thick targets of a pure element. By M. Green and V. E. Cosslett.

A simple theoretical expression is proposed for K quanta production in directions at large angles to the surface of a thick target, neglecting absorption. Direct and indirect production are calculated and the ratio of indirect to total production is shown to be in agreement with experimental results both in magnitude and in independence of over-voltage U. Total production is expressed as a function of atomic number Z and over-voltage U, and is found to vary as $(U-1)^{1\cdot67}$. Values for total production are in fair agreement with experimental values.

A direct measurement of the proton total reaction cross-section for copper at 9·3 mev. By G. W. Greenlees and O. N. Jarvis.

A value of 930 ± 70 mbn has been obtained for the proton total reaction cross section for copper at $9{\cdot}3 \pm 0{\cdot}3$ mev by a poor geometry transmission method and involving counter coincidence techniques. This result, which is in good agreement with values obtained by indirect methods, is appreciably higher than values predicted by published optical model analyses using a volume absorption term. Differential elastic cross sections are presented for the angular range 30°–155° (c.m.). These were obtained using the same target as in the reaction cross section measurement. Good agreement with both the differential cross sections and the reaction cross section can be obtained using an optical model potential with an absorptive term peaked at the nuclear surface.

Photofluorescence decay times of organic phosphors. By T. D. S. Hamilton.

An accurate and convenient method for measuring photofluorescence decay times in the nanosecond region is described. Result are given for a number of organic compounds and reasons for differences with previous results are discussed. Some previous results for quantum efficiencies are corrected on the basis of these measurements and apparent anomalies examined with regard to the mean free path of excitons in very thin crystals.

Temperature effects in domain patterns from single crystals of hematite ($\alpha - Fe_2O_3$). By G. Kaye.

Electron shadow patterns have been used to study the configuration of domains present in single crystals of hematite ($\alpha - Fe_2O_3$) in the temperature range 0 to 700°c. The observations were made using a furnace designed to fit into the specimen chamber of the electron diffraction camera.

It has been found that once a crystal was heated to above its Curie temperature the configuration of domains in the specimen at room temperature is partially stable. Repeated heat treatment of the crystal to above its Curie point leads to a partial "memory effect" similar to that described by Blackman Haigh and Lisgarten in 1957 for the low temperature transition in hematite.

A study of the variation with temperature of the sizes of features in the shadow patterns provides a method of determining the Curie temperature of hematite crystals to an accuracy of 2 to 3°. In this way Curie temperatures between 643°c and 688°c have been observed for crystals from different origins.

Finally an attempt has been made to correlate the Curie temperature of various crystals with their lattice parameters as determined by x-ray powder photographs.

Isotope shift in the CdI resonance line 2288Å. By F. M. Kelly and E. Tomchuk.

The isotope shifts in the singlet resonance line of CdI have been observed. The line was excited by electron bombardment of an atomic beam and the high resolution was obtained with a Fabry-Perot interferometer. The shifts measured in this line (2288Å) are compared with those previously

measured in the intercombination resonance line (43261) to show that the specific mass effect is small. Comparisons are made with similar measurements in magnesium and zinc.

The dependence of capture rate on electric field and the possibility of negative resistance in semiconductors. By B. K. Ridley and T. B. Watkins.
It is pointed out that the rate of capture of electrons and holes by charged centres should depend markedly on electric field strength when this is high enough to produce hot electrons. In particular the capture rate for an attractive centre should decrease while the rate for a repulsive centre should increase as the field rises. Each effect will alter the steady state density of carriers. For the case of repulsive centres a decrease in carrier density will occur and the possibility of using this phenomena to produce a negative resistance state in the semiconductor is discussed. Suitably compensated n-type germanium crystals containing copper, nickel or gold appear to have the requisite properties for exhibiting negative resistance at temperatures low enough for the thermal ionization rate of the centre to be small. It is pointed out that the long time constants involved in the process preclude the use of short pulse fields.

Low-temperature cloud-chamber studies on water vapour. By L. A. Madonna, C. M. Sciulli, L. N. Canjar and G. M. Pound.
The critical supersaturation for the precipitation of water droplets or ice crystals from the vapour was measured between 0°C and −75°C by an expansion-chamber technique. Nitrogen was used as the carrier gas, and measurements were made both in the presence and in the absence of an electric field. The temperature dependence of critical supersaturation was found to be the same in both situations. Thus, existing critical supersaturation data for nucleation of water droplets from the vapour in the presence of an electric field probably represent heterogeneous nucleation on ions. Comparison of the data taken in the presence of a field with the Becker–Doering equation for homogeneous nucleation shows fair agreement at the higher temperatures but marked negative deviation at lower temperatures. The precipitate particles appeared to be spherical above −65°C, while at lower temperatures precipitation was in the form of ideomorphic ice crystals.

The nuclear scattering of high energy photons. By W. S. C. Williams, H. S. Caplan and D. T. Stewart.
The scattering from carbon nuclei of photons in the energy range 50–130 mev has been measured by the use of a total absorption Cerenkov spectrometer in conjunction with a counter telescope. The angular range investigated was 90° to 135°. The results have been analysed by means of a simple model of nuclear charge distribution with nucleon polarizability and indicate the presence of some magnetic dipole scattering. A dispersion relation is applied to check the validity of this simple model.

The importance of conservation conditions in distorted wave calculations. By W. B. Somerville.
Some recent results obtained by Vainstein in 1960, using the Distorted Wave approximation for the 35-36 transition in electron–sodium atom collisions, are modified on the basis of a method introduced by Seaton in 1961 which ensures that the conservation condition is satisfied. The resulting cross sections lie much closer to those obtained by experiment.

The crystalline field parameters for dysprosium ethyl sulphate. By M. J. D. Powell and R. Orbach.
The four crystalline field parameters of the Dy^{3+} ion in the ethyl sulphate, V_4^0, V_4^4, V_6^0, and V_6^4 are fitted at 4·2°K and 58°K to give the known level splittings and g values. It is found that $V_4^0 \sim 125\ cm^{-1}$, $V_4^4 \sim -26\ cm^{-1}$, $V_6^0 \sim -31\ cm^{-1}$ and $V_6^4 \sim 490\ cm^{-1}$, and there exists a slight variation with temperature between 4·2°K and 58°K. These values are, however, in serious disagreement with those obtained by the extrapolation procedure of Elliott and Stevens. In particular, V_6^0 is extraordinarily large, in agreement with the previous work of Judd on europium ethyl sulphate. An empiridal variation of V_n^m with atomic number is given which is in marked contrast with that predicted by Elliott and Stevens.

The magnetic susceptibilities of aluminium-rich transition-metal intermetallic compounds. By Michael A. Taylor.
In aluminium-rich transition-metal intermetallic compounds the behaviour of transition-metal atoms in an electron-rich environment can be studied. Electron density maps, prepared from x-ray data, and considerations of Brillouin zones for these compounds have not, up to the moment, yielded accurate information on the state of the transition-metal atoms. The results of the measurements of the magnetic susceptibilities of some such compounds are given: from these measurements information on the 3d state of the transition-metal atoms is derived.

LETTERS TO THE EDITOR

The effect of absorption in the β filter on the mean wavelength of x-ray emission lines. By B. W. Delf.

Hyperfine structure in terbium metal. By B. Bleaney and R. W. Hill.

The magnetic susceptibility of manganese zinc fluoride solid solutions. By D. M. Finlayson, I. S. Robertson, T. Smith and R. W. H. Stevenson.

The application of Onsager's theory to dielectric dispersion—a correction. By Nora E. Hill.

A note on the band spectra of BiF and SbF. By G. D. Rochester.

The Hall effect in monovalent metals at low temperatures. By S. Simons.

Central Electricity Generating Board

PHYSICS DIVISION

BERKELEY NUCLEAR LABORATORIES GLOUCESTERSHIRE

Applications are invited for posts in these Laboratories. Those appointed will work initially in the following sections, although subsequent transfer between sections will be possible, depending on the developing interests and abilities of the staff concerned.

A. INSTRUMENTATION

For work developing nuclear radiation detectors and other specialized nuclear instruments. Preference will be given to candidates who are capable of devising and developing new techniques of measurement.

B. GRAPHITE

To study the fundamental mechanisms and assess the extent of irradiation damage in graphite and the corresponding changes of physical properties.

C. THEORETICAL PHYSICS

To study various theoretical problems of interest to the Laboratories, including reactor physics and the theory of radiation damage.

● Initial salaries up to **£1,325** per annum are offered, in accordance with experience, ability and qualifications of persons appointed.

Candidates must have a good honours degree and should be under 26 years of age.

Applications stating age, qualifications, experience, present position, salary and quoting type of work interested in, to the Appointments Officer, 24/30, Holborn, London, E.C.1. Quote "Ref. PB/317".

A recent book filling a gap in semiconductor literature

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BELL

COMMONWEALTH OF AUSTRALIA

AERONAUTICAL RESEARCH LABORATORIES

ELECTRICAL TRANSDUCERS

The Department of Supply invite applications for the following vacancy at the Aeronautical Research Laboratories, Melbourne:—

POSITION : EXPERIMENTAL OFFICER GRADE I.
SALARY : £1,290/1,620 (Australian currency). (A substantial increase may be awarded shortly).
DUTIES : Participate in a programme of investigations on electrical transducers with emphasis on electrical resistance strain gauges. The work will include the devising and manufacture of some apparatus and electronic equipment.
QUALIFICATIONS : A Degree in Science or Electrical Engineering, or equivalent qualifications.
TRAVEL : Under certain conditions, first class air/sea transport for the candidate and dependants (wife and dependent children) will be provided by the Commonwealth.
CONTRACT EMPLOYMENT: Consideration may be given to entering into an agreement for a three (3) or five (5) year contract of employment in Australia. In this case the Commonwealth will bear the cost of return fares, together with the cost of removing the successful applicant's furniture and effects up to a maximum cost of £500 (Australian), £250 each way.
APPLICATIONS : Forms obtainable from the Senior Representative, (AV114/6), Department of Supply, Australia House, Strand, London, W.C.2, with whom completed applications should be lodged as soon as possible.

COMMONWEALTH OF AUSTRALIA

WEAPONS RESEARCH ESTABLISHMENT

ROCKET INSTRUMENT RESEARCH

The Department of Supply invite applications for the following position at the Weapons Research Establishment, near ADELAIDE:—

Position: HIGHER SCIENTIFIC OFFICER

Salary: £2,036–£2,296 (Australian currency) (A substantial increase may be awarded shortly.)

Duties: Research on design and development of rocket borne instruments, mainly mechanical and optical, for research in the upper atmosphere.

Qualifications: Honours degree in Science, with Physics and Mathematics as major subjects. Some experience in the above field an advantage.

Note: Applicants who do not possess sufficient experience to warrant appointment as Higher Scientific Officer might be offered employment initially as Scientific Officer Grade 1, within the salary scale £1,541–£1,926 (Australian) per annum. Assistance will be given in obtaining married accommodation.

Travel: Under specified conditions, first class air/sea transport for the successful applicant and dependants (wife and dependent children) will be provided by the Commonwealth.

Contract Employment: If desired by the successful applicant, consideration may be given to entering into an agreement for a three (3) or five (5) year contract of employment in Australia. In this case the Commonwealth will bear the cost of return fares; together with the cost of removing the successful applicant's furniture and effects up to a maximum cost of £500 (Australian); £250 each way.

Applications: Forms obtainable from the Senior Representative (AV.121/5), Department of Supply, Australia House, Strand, London, W.C.2, with whom applications should be lodged by September 8, 1961.

Young Physicists and Textile Technologists

British Nylon Spinners Ltd. has vacancies for young physicists and Textile Technologists as Assistant Technical officers between the ages of 21 and 27 years.

The work will be concerned with New Development on problems connected with Textile Properties. The Physical projects include measurements of the mechanical properties of fibres, yarns and fabrics and investigation of their relation with fabric behaviour. The Textile projects include investigations of the suitability of nylon fabrics for new end uses and the development of test methods.

Physics applicants should possess either a Pass Degree or H.N.C. in physics with laboratory experience. Textile Technologists should possess a Higher National Certificate, A.T.I. Part I plus laboratory experience or A1 of the Higher National Certificate with considerable laboratory experience.

Working conditions are in an ideal country setting with excellent facilities for all sports, and within easy reach of towns.

Rented housing is available for married men. Assistance is given with removal and other expenses.

Applicants are invited to write, quoting T279, to the

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BRITISH STANDARDS INSTITUTION
APPOINTMENT OF TECHNICAL OFFICERS

The B.S.I. invite applications from those with qualifications in engineering or physical sciences to join the technical staff of the Institution. This staff is responsible for the work of the B.S.I. in the preparation of British Standards in co-operation with the various sections of industry and science, and for presentation of the U.K. point of view in international discussions on standards. The technical staff plan and progress the work and act as secretaries to technical committees.

Applicants should have a university degree or equivalent professional qualification.

There are three grades of appointment, with an overall salary range up to £2,000 plus; applications are invited for the grade which has at present a maximum salary of £1,350, the starting salary being dependent on individual qualifications and experience. The posts are pensionable.

Apply to the Establishment Officer, British Standards Institution, 2 Park Street, London, W.1, quoting reference Tech.(G) and enclosing a brief resumé of qualifications and experience.

COMMONWEALTH OF AUSTRALIA

WEAPONS RESEARCH ESTABLISHMENT

OPTICAL TESTING EQUIPMENT

The Department of Supply invite applications for the following position at the Weapons Research Establishment, near ADELAIDE:—

Position: EXPERIMENTAL OFFICER GRADE 1

Salary: £1,321–£1,651 (Australian currency). (A substantial increase may be awarded shortly.)

Duties: Develop optical equipment required for field and laboratory performance testing of lens systems. Carry out necessary performance testing.

Qualifications: Degree in Physics or equivalent qualifications.

Note: Assistance will be given in obtaining married accommodation.

Travel: Under certain conditions, first class air/sea transport for the candidate and dependants (wife and dependent children) will be provided by the Commonwealth.

Contract Employment: Consideration may be given to entering into an agreement for three (3) or five (5) year contract of employment in Australia. In this case the Commonwealth will bear the cost of return fares; together with the cost of removing the successful applicant's furniture and effects up to a maximum cost of £500 (Australian); £250 each way.

Applications: Forms obtainable from the Senior Representative (AV.120/7), Department of Supply, Australia House, Strand, London, W.C.2, with whom completed applications should be lodged by September 4, 1961.

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APPLICATION FORMS AND BOOKLET obtainable from

Assistant Director (Est. 3.R.1.), Ministry of Aviation, Room 509, Adelphi, John Adam Street, LONDON, W.C.2 (quoting MOA. HC/2D/0746/NB).

RADIOLOGICAL PROTECTION SERVICE (Ministry of Health and Medical Research Council), Clifton Avenue, Belmont, Sutton, Surrey, requires the following scientific staff:

1. **Physicist** to develop methods of measuring low doses and dose-rates of ionizing radiation of all types, above background levels and to investigate miscellaneous radiation protection problems.

2. **Physicist** to improve the accuracy of present techniques for the personnel monitoring of ionizing radiation and to investigate methods of measuring air and surface contaminations with radioisotopes.

Qualifications: Good honours degree in physics, or equivalent. Salary: According to age and experience at a point on the scale £910 to £1,310 (London area). Superannuation under N.H.S.S.S. Child allowances.

Applications, with the name and address of two referees, to the Director at the above address.

Central Electricity Generating Board

ELECTRICAL ENGINEERS

OR

PHYSICISTS

Research and Development Department (Headquarters)

Applications are invited for appointments in a section of the Technology Branch.

The Section is responsible for assessing the requirements for research in the electrical engineering field, for promoting liaison between all concerned in such research and for ensuring that the results are applied to best advantage.

The successful candidates will, therefore, be required to keep in close touch with engineering and research activities, within the Board and outside, over a selected field and will need sound judgement and the ability to think constructively.

The appointments will be initially tenable at Headquarters, London, S.E.1, but after approximately 18 months will be at Leatherhead or Marchwood (Southampton) as space in Laboratories there becomes available.

A University degree in Electrical Engineering or Physics is required together with research experience of transmission or associated branches of light current engineering.

● ***Salaries according to qualifications and experience, within the range £1,385 - £1,950 p.a. plus £60 p.a. London Allowance when appropriate.***

Applications stating age, qualifications, experience, present position and salary to the Appointments Officer, 24-30 Holborn, London, E.C.1, as soon as possible. Quote Ref. PB/345.

FOURAH BAY COLLEGE
THE UNIVERSITY COLLEGE OF SIERRA LEONE

Applications are invited for the newly established CHAIR OF PHYSICS. Tenure of the Chair is permanent to the age of retirement but the College would consider an appointment on secondment for a limited period, e.g. 5 years. Salary £2,500 p.a. Negotiations in progress for revision of salary scales. F.S.S.U. Outfit and family allowances (maximum £300). Passages on appointment, annual leave and normal termination. Part-furnished accommodation at reasonable rent. Detailed applications (8 copies) naming 3 referees by August 31, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

HIVAC LIMITED

a Company associated with a major group in the telecommunications field, requires ENGINEERS AND PHYSICISTS for work in the development, production control and application of valves, cold cathode tubes and similar devices. Previous experience in these fields would be an advantage but is not essential. Vacancies exist for both senior and junior staff. The posts are pensionable and offer considerable scope for advancement. Applications, which will be treated in strict confidence, should be addressed to : The Engineer-in-Chief, Hivac Limited, Stonefield Way, Victoria Road, South Ruislip, Middlesex.

WESTERN REGIONAL HOSPITAL BOARD

Regional Physics Department

The following new appointments will shortly be made, for duties arising from the growth of the department's activities. PRINCIPAL PHYSICIST to take charge of the Sub-Department of Radiotherapeutic Physics at the Western Infirmary Glasgow, where a 2,000 curie Orbitron unit was recently installed and a 4 MeV linear accelerator will shortly be provided in a new radiotherapy institute. Experience in hospital physics or in other work involving a detailed knowledge of radiation measurement and control is desirable. (Ref. No. 61/12). SENIOR PHYSICIST to supervise the installation, commissioning and subsequent operation of two 4 MeV linear accelerators. Previous experience of this work is not necessary, as suitable opportunities for further study will be provided. Applicants should be graduates in physics or electrical engineering or should possess equivalent qualifications and should have a few years' experience in research or development or in hospital physics. (Ref. No. 61/13). SENIOR PHYSICISTS for duties in the Sub-Departments of Radiotherapeutic Physics at the Western Infirmary and Royal Infirmary, Glasgow (with duties also at Belvidere Hospital where a new radiotherapy institute is being built). Applicants should be graduates in physics or Associates of the Institute of Physics, and should have a few years' experience in a scientific laboratory (Ref. No. 61/14). SENIOR PHYSICIST to work on problems created by the growing complexity of electronic apparatus used in operating theatres and to collaborate with surgeons, architects and engineers in design studies. The person appointed will be encouraged to broaden his knowledge by travel and by study in other centres. Applicants should be physicists or electrical engineers with a few years' experience in research or in the design and development of electronic equipment (Ref. No. 61/15). PHYSICISTS for training and general duties in radiotherapeutic physics. These posts are suitable for physicists who have recently graduated (Ref. No. 61/16). All of these appointments offer unequalled opportunities for research and advanced study. The Regional Physics Department, which is devoted to the practice of clinical physics on a broad front has an establishment of 60 including 5 Principal Physicists, 10 Senior Physicists and 22 other scientists, supported by a team of 17 technicians. The Department's increasing responsibilities in the application of physics to clinical problems provide unusually challenging opportunities for enterprising physicists and good prospects of promotion. SALARY SCALES: Principal Physicist: £1,750 to £2,125. Senior Physicist: £1,250 to £1,700. Physicist: £650 (pass degree) or £730 (honours degree), rising after a probationary period to £925 and subsequently to £1,150; point of entry according to experience. All posts carry superannuation benefits; annual leave 4 weeks (6 weeks for Principal Physicists). Applications should be sent before September 15 to the Secretary, Western Regional Hospital Board, 351 Sauchiehall Street, Glasgow, C.2.

UNIVERSITY OF LONDON

Readership in Electrical Engineering at Imperial College

The Senate invite applications for the Readership in Electrical Engineering with special interest in the Properties of Materials tenable at Imperial College. Candidates should be capable of initiating and guiding research into the properties of materials such as are related to future developments in electrical engineering. A large well-equipped new laboratory will shortly be available. Salary scale £1,675–£1,975–£2,425 a year plus £80 London Allowance. Applications (ten copies) must be received not later than August 31, 1961, by the Academic Registrar, University of London, Senate House, W.C.1, from whom further particulars may be obtained.

CHEMIST AND PHYSICIST (male) required by Ministry of Aviation, Royal Ordnance Factory, CARDIFF (Assistant Experimental Officer/Experimental Officer grade). Experience: Post 1; Ref. F388/1A. Knowledge of analysis of ferrous and non-ferrous metals, electroplating solutions, etc.; heat treatment, electro-plating and metal finishing. Post 2; Ref. A268/1A. Knowledge of the health physics associated with radioactivity and toxicity. Quals.: Pass degree, H.N.C. or equivalent in Chemistry or Physics; G.C.E. (A.L.). Salary: A.E.O. £598 (age 21) – £983; E.O. (min. age 26) £1,087 – £1,336. Opportunities (normally for those under 31) to compete for established (non-contributory pensionable) posts. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate reference.

MAKERERE UNIVERSITY COLLEGE — EAST AFRICA

Applications are invited for (*a*) LECTURESHIP or (*b*) ASSISTANT LECTURESHIP IN PHYSICS. Salary scales: (*a*) £1,350 – £2,151 p.a.; (*b*) £1,098 – £1,251 p.a. Entry point determined by qualifications and experience. F.S.S.U. Child allowance £50 p.a. per child (max. £150 p.a.). Passages for appointee and family (up to 5 adult passages) on appointment, termination and leave (3 months every 21 months). Rent according to quarters provided £45 to £84 p.a. (including basic furniture). Detailed applications (6 copies) naming 3 referees as soon as possible to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

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